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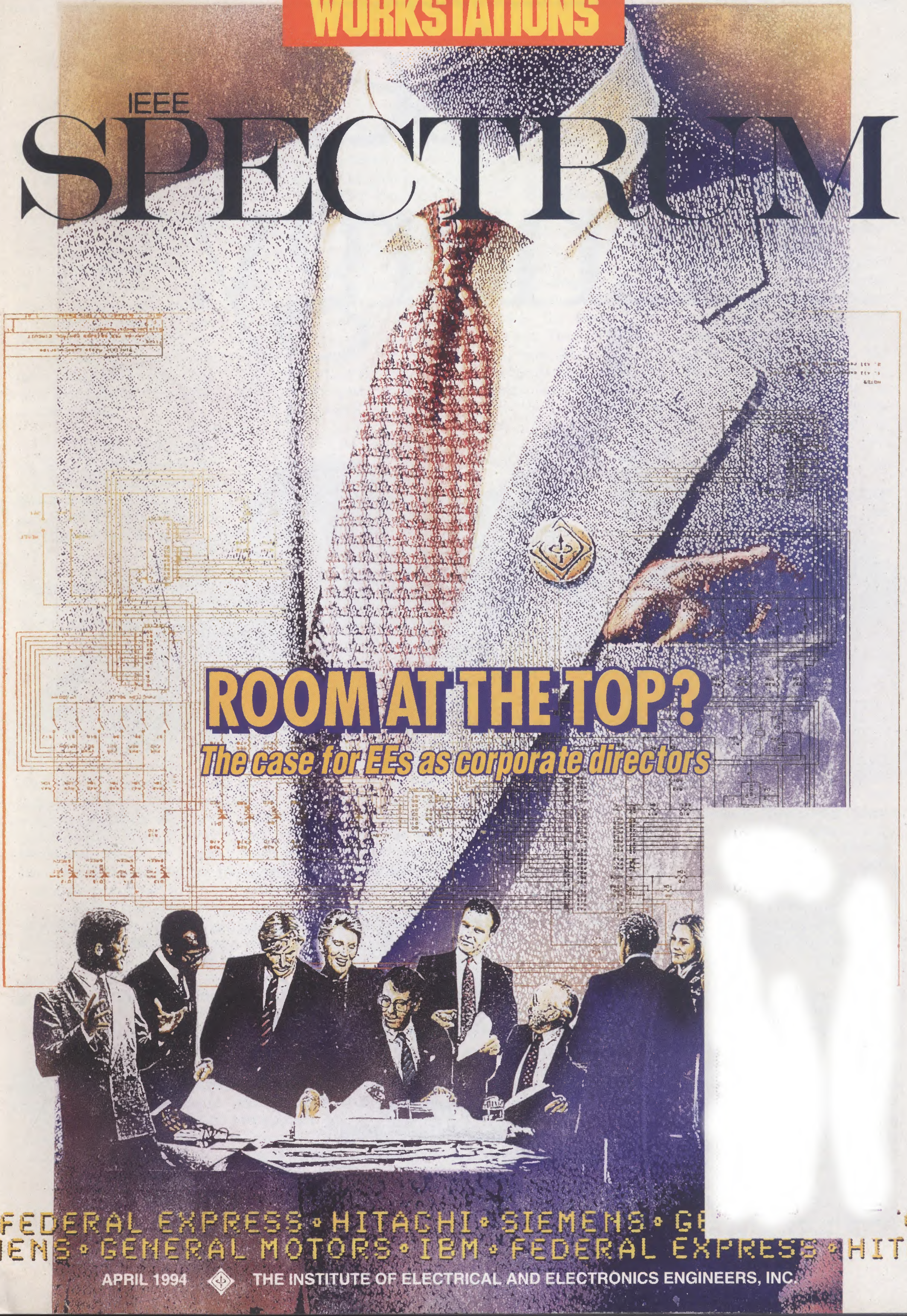

ROOM AT THE TOP?
The case for EEs as corporate directors

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Circle No. 4

Newslog

FEB 3. The **Computer Emergency Response Team**, based at Carnegie Mellon University in Pittsburgh, issued a warning that unknown assailants had been breaking into scores of government, corporate, and university computers connected to the **Internet**. The team said the intruders secretly planted sophisticated software in Internet computers to steal passwords and electronics addresses, and it advised computer administrators to make sure users change their passwords frequently.

FEB 10. AT&T Co. said it would cut up to 15 000 jobs—15 percent of the workforce—in its core long-distance business during the next two years. The cuts will include 8000 managers.

FEB 11. Electronic Power Technology Inc., Norcross, Ga., said it had broken the world record for distance traveled in 24 hours by an electric vehicle by means of a device that recharges batteries in minutes, not hours. An electric Chevy S-10 pickup truck traveling about 55 km per hour covered 1340 km, 320 km more than the previous 24-hour record. The company used a computer-controlled charger that crammed 16 kWh of electricity into the pickup truck in under 19 minutes, enough to power the truck about 105 km.

FEB 11. NASA said the space shuttle **Discovery,** carrying the first Russian astronaut ever to be launched in a U.S. spacecraft, had returned to earth after an eight-day mission. The flight made history with its U.S.-Russian partnership, but transmission troubles and a bad guidance system prevented the crew from deploying a science satellite that was supposed to grow high-grade semiconductor films in the pure vacuum of space.

FEB 14. Hewlett-Packard Co., Palo Alto, Calif., said it had developed versions of amber (592-mm) and reddish orange (615-mm) light-emitting diodes (LEDs) that will be four times brighter than other aluminum indium gallium phosphide LEDs now on the market. The greater brightness is made possible by fabricating the AlInGaP LEDs on a transparent gallium phosphide substrate rather than on light-absorbing gallium arsenide, as is usually done. The company expects the new LEDs to outperform and replace incandescent lamps in certain applications.

FEB 14. The **Clinton administration** said it would initiate sanctions against **Japan** for failing to live up to a 1989 trade agreement to allow **Motorola Inc.**, Schaumburg, Ill., to penetrate Tokyo's cellular phone market. A preliminary list of sanction targets—Japanese phone makers that sell in the United States—is to be drawn up in 30 days.

FEB 15. Viacom Inc., New York City, said it had edged out its rival, **QVC Network Inc.**, West Chester, Pa., in a deal worth about $10 billion to buy **Paramount Communications Inc.**, New York City. Viacom's allies in the four-month battle included Blockbuster Entertainment, which will merge with Viacom, and Nynex, the regional Bell company. The deal will result in what will become the second largest media conglomerate after Time Warner Inc.

FEB 16. The **Digital HDTV Grand Alliance**, the U.S. industry group that formed last year to propose a standard for HDTV systems, said it had chosen the vestigial sideband (VSB) system of **Zenith Electronics Corp.**, Glenview, Ill., over the quadrature amplitude modulation (QAM) system of **General Instrument Corp.**, headquartered in Chicago. A complete HDTV system is scheduled to be tested late this year, with final field testing in early 1995. The first of these HDTV systems is to be on the market by 1997.

FEB 16. The Clinton administration announced that the Saudi Arabian carrier **Saudia** had selected **McDonnell Douglas Corp.**, Long Beach, Calif., and **Boeing Co.**, Seattle, Wash., to supply 50 to 60 planes to replace the Saudis' commercial jets. The US $6 billion deal is expected to preserve tens of thousands of jobs at the companies and their subcontractors, the Pratt & Whitney division of United Technologies Corp. in Connecticut and General Electric Co. in Ohio.

FEB 22. The director general of the broadcasting administration bureau in Japan's **Ministry of Posts and Telecommunications** announced that the Government was considering abandoning the nation's analog HDTV system in favor of one using digital technology. The announcement stunned and angered the nation's television manufacturers, who for 30 years have spent billions of yen to promote and sell analog HDTV. A day later, the director general retracted his statement and said the ministry would continue to promote the existing system.

FEB 22. Canon Inc., Tokyo, and **IBM Corp.** said they have agreed to jointly develop and manufacture small computers using PowerPC microprocessors. The Japanese company is one of the few computer makers beyond the three companies that jointly developed the PowerPC—IBM, **Apple Computer Inc.**, and **Motorola Inc.**—to commit itself to using the new chip.

FEB 23. Bell Atlantic Corp., Philadelphia, said its plans to acquire cable-television giant **Tele-Communications Inc.**, Denver, Colo., in a $33 billion deal had collapsed. The companies said a new Federal rollback in cable rates and the unsettled regulatory climate had derailed the merger that was to have led the U.S. race into the interactive TV age.

FEB 28. MCI Communications Corp., Washington, D.C., said it would invest $1.3 billion for a 17 percent stake in **Nextel Communications Inc.**, Rutherford, N.J. MCI will market Nextel's digital wireless telephone, data, and paging services under the MCI name and will package them with its existing long-distance service. Nextel will gain the cash it needs to build wireless networks around the country.

MAR 1. A consortium consisting of Spain's **Telefónica de España SA** and three Peruvian companies said it had agreed to purchase a controlling stake in the state-operated Peruvian telephone system for $2 billion. The package includes a 35 percent interest in Peru's long-distance service Entel and a 20 percent stake in CPT, which provides local phone service to Lima. Peru has the lowest level of phone provision in South America—about 2.6 lines per 1000 inhabitants.

MAR 1. NEC Corp., Tokyo, and **Samsung Electronics**, Seoul, said they would form a joint venture to develop 256-Mb dynamic RAMs. Last year Samsung became the world's largest DRAM producer. Analysts believe samples of the 256-Mb chips are likely to be available in 1997 or 1998.

Preview:
APR 26–28. The **National Conference on Manufacturing Technology** is to be held at the National Institute of Standards and Technology (NIST), Gaithersburg, Md. Among the featured speakers at the conference will be NIST director **Arati Prabhakar**. For more information, call 301-975-4513.

Sally Cahur

APRIL 1994 / VOLUME 31 / NUMBER 4

IEEE SPECTRUM

FOCUS REPORT

Hewlett-Packard Co.

Cover: At a growing number of large companies, the boardroom doors have opened to electrical engineers, as artist Scott Gwilliams suggests in his cover illustration. Corporate directors with EE backgrounds can bring new perspectives to a board's deliberations and build its confidence in technology-related decision making. See p. 20.

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Forum

Rules and responses

I was surprised and pleased with the responses to my article, "DOs and DON'Ts for young EEs" [October, p. 59]. In addition to those printed in *IEEE Spectrum*, I have received several letters and quite a number of calls.

W. Travis Walton's three additional rules are all good [December, p. 7]. Other relevant advice is that given to Luis Alvarez, Nobel Laureate and man of many inventions and ideas, by his father: "He advised me to sit every few months in my reading chair for an entire evening, close my eyes, and try to think of new problems to solve. I took his advice very seriously and have been glad ever since that I did" (*Alvarez—Adventures of a Physicist*, Basic Books, p. 58).

My advice on avoiding the "fringes of engineering," apparently a poor choice of words, received the most attention and criticism in the Forum letters (but not in the letters and calls I received). Before commenting, I want to make four points:

As noted in the title, my article was directed to *young* engineers.

There are a number of extremely valuable specialists of supreme technical competence in most organizations. I have been privileged to work with many of them. In my experience, these individuals have been older, more experienced engineers who started out in the design area.

In my language, any design engineer worthy of the name designs reliable, manufacturable, supportable equipment and makes full use of those specialists (in or out of the company) required to do this.

Any designer, or anyone else for that matter, who has an elitist attitude toward others does not understand the problem nor how best to accomplish his job.

Now for some comments. The experiences that led me to the "avoid" advice started during the defense cutbacks of the late '60s when I received a number of calls and letters from defense engineers who had been laid off. A few were friends and former colleagues; most were people I did not know or had met only briefly. The vast majority and *all* of the younger ones (five years or less out of school) were in what I called the "fringes of engineering." This experience has repeated itself to a degree at subsequent cutbacks including the present one. Most managers feel, rightly or wrongly, that it is easier to cover most non-design requirements with design engineers than vice versa and that the key to survival in tough times is preservation of design capability. Again I must note that most companies have a few valuable specialists in key areas whose jobs are as safe as that of any design engineer.

There are challenging technical jobs—jobs that have to do with how things work, with the fundamentals—in the system, subsystem, and component areas. Some of these jobs are in the "ilities" groups; most are in the design groups. There are other jobs that are somewhat peripheral, whose content is more descriptive than technical. These tend to be in the "ilities" areas. My advice to the young engineer was to avoid the latter in favor of the former.

There are important, responsible jobs in the non-design areas, and as the article said, "if that's your bent, there is always time for such moves later on."

There has been an unfortunate tendency in some "ilities" groups (government and contractor) to become an end unto themselves.

Samuel A. Bogen chastised me for referring to men by their last names and women by their first names [December, p. 7]. I am surprised that in this day and age anyone would assume that a surname indicated a male. The examples were derived from actual cases where the last name happened to be used in three instances and the first name in one. One of the three surnames belonged to a woman. Fortunately for all, women EEs are right in there contributing their share of bright new ideas.

Finally, I cannot see where Bogen's other criticism holds water. Nothing could be more gender neutral, surely, than a woman doing what used to be considered (and still is in this household) "man's work"—carrying out the garbage.

Charles A. Fowler
Sudbury, Mass.

The IEEE's importance

I enjoyed the career profile of Arati Prabhakar [December, p. 48]. I think it highlights the fact that young engineers today *can* make a mark for themselves in industry and government.

While the article does stress the important role of mentors, it fails to mention the equally important role that the IEEE can play. Aside from mentioning that Prabhakar headed the IEEE Student Branch and obtained her first job through an advertisement in an IEEE newsletter, there was no mention of how membership and involvement in the IEEE helped her career.

As a young engineer, I have found that the IEEE is helping me to develop my technical and professional skills. I also believe that my continued involvement in the IEEE will help me when I am ready to move into a management function. Active involvement in the IEEE (at the Student Branch, Section, and Region levels) has also provided me with an abundance of technical resources and many new friends.

In my capacity as Chair of the Region 7 (Canada) Student Activities Committee, I have found that students are very interested in how the IEEE can help them now while they are in school and later when they will be working. Documenting real-life stories may help in our effort to reverse the trend of declining student membership and bolster our bid to retain more recent graduates as members.

Timothy K. Chia
Vancouver, B.C., Canada

On the evidence

The letter from John G. Sinclair Jr. [February, p. 4] prompted me to read *Currents of Death* by Paul Brodeur. The book is a review of anecdotal evidence without a single reference to the literature. The reader is never quite sure whether any given allegation is being attributed to electrical, magnetic, or electromagnetic (propagating) fields.

The author gives considerable attention to effects of radio waves and states that these waves must be amplitude modulated in a particular way to have the effects claimed for them. He points out, correctly, that 50 and 147 MHz are frequencies used by radio amateurs. Is he aware that such amateur signals are rarely amplitude modulated?

Brodeur repeatedly claims that the only valid research in these areas is that conducted by persons with training in biological fields, rather than by engineers. It seems clear that both kinds of expertise are needed if we ever expect to understand what forms of radiation are harmful, if any.

I can only compare the book unfavorably to other works I have read recently. For example, the studies of diet and health by John McDougall are painstakingly documented. The same is true of the writing of Marc Reisner, who has shown us how the availability of subsidized water for crops such as cotton and feed grains inappropriate in the West has led directly to water shortages and environmental damage. As a writer, Brodeur cannot hold a candle to a McDougall or Reisner.

Because of a personal interest in dietary matters, I have become somewhat interested in "alternative medicine." There is an individual in this region who is consulting in the area of electromagnetic effects on individu-

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Circle No. 3

als. This person has no special training in either engineering or biology. The recommendations offered do not end with removing electric blankets. All electrical wiring must be removed from bedrooms. Mirrors must be installed to reflect "bad energy."

Another consultant in the area who is an M.D. believes that hair dryers and toasters emit microwaves. As engineers, we can provide a balance to this kind of information if we are well informed.

Robert G. Huenemann
La Honda, Calif.

Having read much of the literature concerning the EMI/cancer controversy, including that of the environmental gadfly Paul Brodeur, I have yet to see any epidemiological study on electromagnetic interference that takes into account other environmental factors that *may* have caused cancer in humans—particularly in those who work for electrical and telephone utilities.

Utility workers are routinely exposed to other elements that have been linked to cancer: conduits that were made from asbestos, chemical solvents such as carbon tetrachloride and Freon, vapors from lead solder, vapors emitted when skinning Teflon wire, capacitor and transformer oil containing polychlorinated biphenyls, and lastly the person's genetic predisposition to getting cancer regardless of occupation.

Having had cancer myself, I am loath to accuse any one factor that I have encountered over the years: 25 years of being a ham radio operator, 30 years in the electronics profession, 15 years of handling darkroom chemicals, or a lifetime of breathing polluted air.

I would admonish all serious investigators to use caution when drawing conclusions about the relationship of *any* factor in causing cancer. Statistics can and very often do lie.

H. Robert Schroeder
Trenton, N.J.

It is particularly distressing that any IEEE member would cite a work by Paul Brodeur, since it has been shown before that Brodeur has no apparent technical background and rarely uses refereed references in any of his exposés. Also, Brodeur's books are specifically designed to sell by catching the public's attention with such alarming titles as *The Zapping of America* and *Currents of Death.* While Brodeur's books may be instructive on the current position of a vocal minority of concerned people, they provide little technical justification for anything else.

I agree that the Swedish government has embarked on a significant set of studies into health effects from all types of radiated fields. Like the Wirtheimer study so frequently referenced by the anti-groups, however, there are some inherent flaws that must be taken into account before using these documents as gospel. The Wirtheimer (Denver) study has been the subject of many critical analyses and other eminent experts have demonstrated its flaws from an electromagnetic theory point of view as well as revealing significant weaknesses in statistical analysis.

There is absolutely no doubt that fields *concern* a great many people. The question before the house is: how serious is the problem? Should we as a society spend millions or billions of dollars trying to solve a problem that may not be demonstrably dangerous to the majority of our population, especially in light of other rather more pressing domestic priorities?

Until we develop an acceptable methodology to determine critical thresholds of observable bioeffects and commission the appropriate studies, what we have today is a bunch of interesting paper that can be (and often is) the subject of endless arguments.

Bill Hickey
Boulder, Colo.

Flying by

Gerald C. Ansell's comments on the Global Positioning System (GPS) in transoceanic airliners [January, p. 6] show a surprising naiveté. GPS is not yet approved as the sole means of navigation of aircraft under instrument flight rules (IFR). Approval is expected, but it is not yet legal to use for aeronautical navigation.

I am sure that the British Airways 747-400 aircraft was equipped with a triple-redundant inertial navigation system (INS) to navigate its transatlantic system. INS is a self-contained system that uses accelerometers and mathematical integration of inertial forces to calculate position. It has an accuracy of about one mile per hour of operation. It will bring the aircraft reliably within the range of ground-based navigation systems (VOR, ILS, NDB, and others) at a destination anywhere in the world.

GPS is cheaper (lower-cost on-board equipment), more accurate, and probably more reliable, but is not yet approved for use in these circumstances.

Israel Switzer
Toronto

Yes, small is beautiful

Robert Troy writes, in "It's time to make software development an industrial process" [January, p. 40], that we need to get rid of the "mythology of hand craftsmanship" that he sees as interfering with quality in software development. What we need, in fact, is to do much the opposite. We need to get away from the current practice of developing software on the equivalent of assembly lines, where a single large project is undertaken by separate teams of designers, coders, testers, integrators, documenters, and customer support personnel. We need to stop looking for ever more powerful tools for managing large programs, and do things in the way they have traditionally been done in academic environments where Unix is popular: create small, highly interoperable tools that can be interconnected into larger systems.

Every program I have ever encountered that was truly well designed and satisfactorily free of bugs has been, in essence, the creation of one person. Examples that come to mind are the original Turbo Pascal, the original Lotus 1-2-3, and the Brief editor used by many programmers. Recent large and popular programs I have seen have been riddled with bugs to the point where my eyes glaze over. I am amazed that people (myself included) tolerate the stuff that is showing up in the marketplace.

Why do these software disasters happen? I believe it is because there is simply no way to produce quality code in large teams; the problems of communication and organization are just too severe, and attention to detail falls by the wayside. The way to deal with the problems found in writing large programs is simply to stop writing large programs! We have more tools available than ever before to make small, modular programs interoperate better, but the concept of a person writing a program seems to be anathema in today's large software houses.

Until I am shown otherwise, the best explanation I can see for this sorry state of affairs is not technical, but political. Employers of programmers really do not *want* them to have a sense of involvement with their work. As I heard it put recently in a large corporate environment: "The quality of our products does not depend on individuals; it depends on the process." While advisors such as Tom Peters will tell you that the way to get quality is to provide workers with a chance to be a star, I really think this is the last thing that most of those who make the decisions want to hear.

Ronald W. Garrison
Durham, N.C.

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Graphics

Going to pieces

The world of everyday experience is a world of motion. Water flows, drips, and sprays; snowflakes swirl; flames leap and quiver; sparks fly; smoke curls; fog drifts moodily. Until recent years, though, convincing renditions of such kinesis eluded most computer graphics animators, leaving a distinct gap in their ability to portray natural phenomena.

Now filling the void are so-called particle systems, which, as their name implies, portray objects as collections of minute specks of color or texture. "Motion and fluidity are the essence of particle systems," notes William T. Reeves, a pioneer of the technique. "It's just lots of teeny-weeny things moving, and possibly evolving." *En masse*, the specks are made to imitate vivid waterfalls or spectacular fireworks, say, by appearing to obey various physical laws, like gravity. Often, the particles have a limited "life," with "old" ones disappearing and new ones taking their place.

More conventional computer graphics, on the other hand, uses hordes of colored polygons to represent the surfaces of two- and three-dimensional shapes. It is well-suited to representing objects—an automobile, for example—but is poor at showing exhaust coming out of its tailpipe.

The general ideas behind particle animation have been known to graphics specialists for over a decade. Around 1980, Alvy Ray Smith and James Blinn used them to model galaxies for "Carl Sagan's Cosmos," an educational series produced for U.S. public television. Several years later, Reeves used them to produce a milestone effect for the motion picture *Star Trek II: The Wrath of Khan* and wrote a related paper for the 1983 Siggraph conference. It was only then that the principles began gaining recognition and cohesion as a separate graphics technique.

"People had been concentrating so hard on curved surfaces," Reeves recalled. "I thought, that's OK for some things—a lot of things, frankly. But it's a nice twist of the brain to think of something different, something that works better for certain situations." Reeves's seminal effort was a planet exploding in a wall of fire at the beginning of the film.

Another high point in these formative years was the animation "Particle Dreams," which premiered at the 1988 Siggraph conference in Atlanta, Ga. The animator was Karl Sims of Thinking Machines Corp., Cambridge, Mass., and his four sequences depicted swirling fire, a face made up of particles, a blizzard, and a waterfall—supposedly the first in a computer animation. "It was the best use of particle systems I've seen," said Reeves. "It wasn't subtle at all, just gorgeous."

"It was that animation that got me into particle systems," said Cassidy Curtis, an animator and programmer at Xaos Inc., a San Francisco–based computer graphics and design firm specializing in particle animation.

Recently, there has been an explosion, so to speak, in the use of particle animation, especially in television programs and advertisements. The Music Television (MTV) network, for example, counts down the top 20 music videos with what seem to be brightly colored inks running down a transparent panel, leaving dripping, black numbers behind. The NBC network has commissioned a new identification sequence that shows spark-like particles coalescing into the network's trademark peacock icon [illustration, below].

The technique has also been used in advertisements for Nike athletic footwear, Efferdent denture cleaning tablets, Jolly Rancher candy, and many other products. One memorable motion-picture effect was the sequence in the movie *Lawnmower Man,* in which a young man literally fell to pieces.

All of these, moreover, constitute just part of the work done recently by Xaos (pronouced "chaos"). "It's gotten to the point where we use the particle software for almost every job we do, either as the main effect or as something layered on top of the effect," said Curtis.

Curtis wrote the particle system within Xaos's proprietary software, which also includes image-processing capabilities and was produced by a number of programmers over the past five years. In simplest terms, the particle system lets the animator specify the appearance of particles and the forces acting on them. Newton's laws relating force, mass, and acceleration are often the starting point, "but the particles can also interact with each other," Curtis explained.

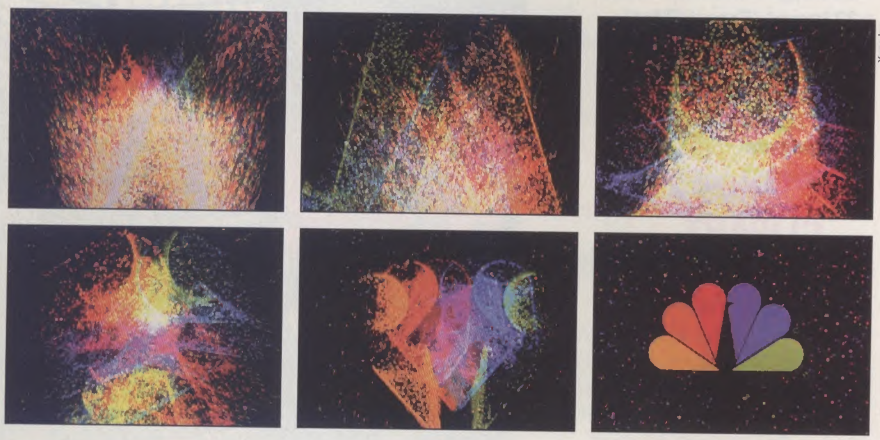
Compared to polygon-based graphics, in which every shape, angle, and shade must be precisely specified, particle-based animation is an exercise in demagoguery. "In general, you give the particles an environment to work in, and forces to respond to, and then let them go," Curtis said. And therein lies both the beauty and the frustration of the technique.

To create the well-received MTV countdown sequence, for example, Curtis induced those colorful inky liquids to coagulate into numerals by specifying forces, similar in effect to magnetic ones, that would draw the "liquid" into the appropriate shape—a 5, say. It worked poorly for some numbers, though; the 2, for example, emerged as a stooped 7. So he had to tweak the code, making the numeral form less "magnetic" in places, in hopes of getting the "fluids" to run down and congeal on the numeral's bottom horizontal line.

Such tweaking must be done with care, or else the effect will lose the naturalistic quality that is the lure of particle animation in the first place. "You relinquish a lot of the control that animators typically have, in exchange for the natural effect," Curtis noted.

Many animators are devising ingenious ways to marry particle animation to other techniques, usually polygon-based ones. In the mid-1980s, Reeves and Alain Fournier, now at the University of British Columbia in Vancouver, Canada, tackled one of the toughest challenges in computer animation: producing a realistic-looking portrait of the surging, rolling surface of the sea. They used a technique called bi-cubic surface modeling, implemented as a grid, to model a finely rippled sea surface, and resorted to particle techniques for the spray and foam.

Glenn Zorpette



Xaos Inc.

A particle-animated version of the National Broadcasting Co.'s peacock logo was created by Mark Malmberg, creative director of Xaos Inc., a San Francisco–based computer animation and design firm. Some 70 000 spark-like particles coalesce into the colorful icon.

The Apple Report On PowerPC

Number 3 – Power Macintosh for Technical Users

If you use applications that do floating-point mathematical calculations, your performance levels could be up to ten times faster than those of the same program running on a 68040 machine—and several times faster than the fastest Pentium system–based computers.

The PowerPC chip is the first workstation-level microprocessor ever introduced in a mainstream personal computer. In fact, many workstation developers are now writing applications for Power Macintosh computers.

A Power Macintosh offers unprecedented compatibility between Macintosh, MS-DOS and Windows environments, thanks to an emulation program called SoftWindows, which licenses actual Windows code from Microsoft.

If you buy a 68040-based Macintosh today, can you upgrade it tomorrow? In a word, yes. Just look for the "Ready for PowerPC upgrade" sticker on the box.

For more information about Power Macintosh computers for technical users, give us a call at 1-800-732-3131, ext. 350. In Canada, call 1-800-665-2775, ext. 910.

Power Macintosh™ computers are here. Apple's new generation of Macintosh® computers are powered by the PowerPC™ microprocessor, a chip developed jointly by Apple, IBM and Motorola.

Accelerated for Macintosh with PowerPC™

With these Macintosh computers, you can expect to see speed and functionality increase dramatically, while prices remain the same – or even drop. And if you're an engineer, architect or other power user working with large, complex files, you can also expect to see significant increases in productivity.

For the first time, a personal computer can offer you the kind of power that was previously available only in high-performance, high-cost workstations.

More compatible personal computers.

Of course, a Power Macintosh is still a Mac,® so it's compatible with your present Macintosh computers, peripherals, software and files. You can also run most current DOS and Windows programs, thanks to a program called SoftWindows, which licenses Windows code from Microsoft.*

The real benefit of Power Macintosh computers, however, will be seen with new applications optimized to take advantage of the chip's advanced capabilities.

Developers move to Power Macintosh.

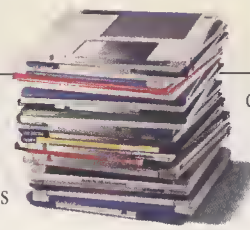
Applications optimized for the new Power Macintosh computers, often called native applications, will offer two to four times the performance – and in the case of some programs that perform floating-point mathematical calculations, ten times the performance – of programs available for the fastest Macintosh computers today.

Right now, the world's leading developers are updating their most popular programs to take full advantage of Power Macintosh computers *(see box)*. In fact, Apple has been working closely with more than 200 major third-party developers since 1992 to create new versions of their applications. And hundreds of additional developers have begun the move to PowerPC.

What about software?

A Power Macintosh will run virtually all of your existing Macintosh system–based programs. The real benefit of a Macintosh with PowerPC technology, however, will be with applications optimized to take advantage of the new chip's advanced capabilities. Here are some of the native applications that are available now or will be out in the next few months.

Abacus StatView
Alias Sketch!
Ashlar Vellum
auto•des•sys form•Z
Electric Image ElectricImage Animation System
GraphiSoft ArchiCAD
Graphsoft MiniCad
Gryphon Morph
Imagine That! Extend
Insignia Solutions SoftWindows
ITEDO IsoDraw
Knowledge Revolution Working Model
MacroMedia MacroModel
Microsoft Excel
Microsoft Word
National Instruments LabView & HiQ
Specular Infini-D
Strata StudioPro
VIDI Presenter Professional
Virtus WalkThrough
Wolfram Research Mathematica



Get more done, faster.

There are immediate benefits to running native applications on a Power Macintosh computer: You spend less time waiting for the computer to complete complex tasks. So you can do more work in less time.

This is especially significant for applications that require a lot of processing power – CAD programs and programs that perform floating-point mathematical calculations, for instance – as well as for larger or more complex files.

Developers will also be exploring new features in areas such as intelligent help, 3-D design, video and animation, speech recognition and text-to-speech conversion. These are functions that simply wouldn't be practical without the superior processing capabilities of the PowerPC chip's RISC-based architecture and innovative Macintosh technology.

Why RISC?

The new generation of Macintosh computers are the first personal computers with RISC (Reduced Instruction Set Computing) chips. RISC chips are smaller and more efficient than comparably powered CISC (Complex Instruction Set Computing) chips, so they cost less to produce.

Which means not only will Power Macintosh computers offer you substantial performance increases, they will do so far more affordably than a CISC-based system can. In other words, they'll provide you with unprecedented power.

The power to be your best.® Apple®

Calendar

APRIL

Transmission and Distributed Conference and Exhibition (PE, Chicago Section); April 10–15; McCormick Place, Chicago; John J. Viera, Commonwealth Edison, Box 767, Chicago, IL 60690; 312-294-3333.

International Reliability Physics Symposium (ED, R); April 11–14; Fairmont Hotel, San Jose, Calif.; Richard Blish, Intel Corp., 5000 W. Chandler Blvd., Chandler, AZ 85226; 602-554-4127; fax, 602-554-6098.

Third Maghrebian Conference on Software Engineering and Artificial Intelligence (C); April 11–14; Hyatt Regency Hotel, Rabat-Agdal, Morocco; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, DC 20036-1992; 202-371-1013; fax, 202-728-0884.

Position, Location and Navigation Symposium—Plans '94 (AES); April 11–15; Bally's Hotel, Las Vegas, Nev.; Michael Hadfield, 12449 84th Way N., Largo, FL 34643; 813-531-5715.

12th European Photovoltaic Solar Energy Conference and Exhibition—PSEC (ED); April 11–15; RAI Congress Centre Amsterdam, the Netherlands; Heinz Ehmann/Andrea Zepf, WIP—Munich, Sylverstinstr. 2, D-81369, Munich, Germany; (49+89) 720 12 32; fax, (49+89) 720 12 91.

13th Annual International Phoenix Conference on Computers and Communications (C, COM); April 12–15; YWCA, U.S. Leadership Development Center, Phoenix, Ariz.; Lana Ruch, American Express, 10030 N. 25th Ave., Phoenix, AZ 85021; 602-548-6025; fax, 602-548-6060.

Third International Conference and Exhibition on Multichip Modules (CPMT); April 13–15; Currigan Exhibition Hall, Denver, Colo.; Richard Breck, ISHM, 1850 Centennial Park Dr., Suite 105, Reston, VA 22091; 800-535-4746, ext. 230.

International Symposium on Speech, Image Processing and Neural Networks (SP, Hong Kong Section); April 14–16; Hong Kong Convention and Exhibition Center; Chorkin Chan, Department of CS, University of Hong Kong, Hong Kong; (8+52) 859 7075; fax, (8+52) 559 8447; e-mail, cchan@csd.hku.hk.

21st International Symposium on Computer Architecture (C); April 18–21;

IEEE members attend more than 5000 IEEE professional meetings, conferences, and conventions held throughout the world each year. For more information on any meeting in this guide, write or call the listed meeting contact. Information is also available from: Conference Services Department, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, NJ 80055; 908-562-3878; submit conferences for listing to: Ramona Foster, *IEEE Spectrum*, 345 E. 47th St., New York, NY 10017; 212-705-7305.

For additional information on hotels, conference centers, and travel services, see the Reader Service Card.

Westin Hotel, Chicago; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, DC 20036-1992; 202-371-1013; fax, 202-728-0884.

International Conference on Requirements Engineering (C); April 18–22; Broadmoor Hotel, Colorado Springs, Colo.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, DC 20036-1992; 202-371-1013; fax, 202-728-0884.

International Symposium on Theoretical Aspects of Computer Software (C); April 19–21; Tohoku University, Sendai, Japan; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, DC 20036-1992; 202-371-1013; fax, 202-728-0884.

International Conference on Acoustics, Speech and Signal Processing (SP); April 19–22; Adelaide Convention Center, South Australia; Phil Plevin, Plevin & Associates Pty., Box 54, Burnside 5066, South Australia; (61+8) 379 8222; fax, (61+8) 379 8177.

Southwest Symposium on Image Analysis and Interpretation (SP, Dallas Section); April 21–22; Grand Kempinski Hotel, Dallas; Alireza Khotanzad, Southern Methodist University; 214-768-3101; fax, 214-768-3883; e-mail, kha@seas,smu.edu; or Nasser Kehtarnavaz, Texas A&M University; 409-845-8371; fax, 409-845-6259; e-mail, kehtar@ee.tamu.edu.

Princeton/Central Jersey Sarnoff Symposium (LEOS, MTT, ED); April 22; David Sarnoff Research Center, Princeton, N.J.; S. Phillips, IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855-1331; 908-562-3893; fax, 908-562-1571.

Rural Electric Power Conference (IA); April 24–26; Sheraton Colorado Springs Hotel, Colorado; Donald E. Werner, Omaha Public Power District, 444 South 16th St., Mall, Omaha, NE 68102-2247; 402-636-2585.

International Workshop on Computer-Aided Modeling, Analysis, and Design of Communication Links and Networks—Camad '94 (COM); April 24–27; Princeton Marriott Hotel, New Jersey; Benjamin Melamed, NEC USA Inc., 4 Independence Way, Princeton, NJ 08540; 609-951-2450; fax, 609-951-2499.

ACM Conference on Human Factors in Computer Systems (C); April 24–28; Hynes Convention Center, Boston; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, DC 20036-1992; 202-371-1013; fax, 202-728-0884.

VLSI Test Symposium (C, Philadelphia Section); April 25–28; Cherry Hill Hyatt Hotel, New Jersey; Prab Varma, CrossCheck Technology, 2833 Junction Ave., San Jose, CA 95134; 408-432-9200; fax, 408-432-0907; e-mail, prab@crosscheck.com.

44th Electronic Components and Technology Conference—ECTC '94 (CHMT); April 30–May 5; Washington Hilton Hotel, D.C.; James Bruorton, Kernet Electronics, Box 5928, Greenville, SC 29606; 803-963-6621; fax, 803-963-6521.

MAY

Custom Integrated Circuits Conference—CICC '94 (ED, SSC); May 1–4; Town & Country Hotel, San Diego, Calif.; Melissa Widerkehr, Widerkehr and Associates, Suite 610, 1545 18th St., N.W., Washington, DC 20036; 202-986-2166; fax, 202-986-1139.

44th Electronic Components & Technology Conference—ECTC (CPMT); May 1–4; Washington Hilton, District of

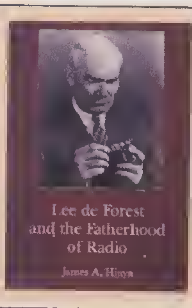
(Continued on p. 85)

Books

Sympathy for de Forest

Hugh G. J. Aitken

Lee de Forest and the Fatherhood of Radio. *Hijiya, James A., Lehigh University Press, 1993, 182 pp., $32.50.*



I began reading this book with some trepidation. The blurb on the dust jacket described it as "not a study in the history of technology but in the history of the religion of technology." And it went on to say that, for de Forest, invention was a substitute for religion. "The good that his inventions did for humanity—his contribution to progress—would give meaning to his existence."

This is all very well, and I take religion as seriously as the next person, perhaps more so. But I also take technology seriously, and it had never occurred to me to characterize technological progress as a search for religious enlightenment. We live and learn. In this case, we read and learn.

It was also not my first exposure to Jim Hijiya's manuscript. Several years before, I had visited Foothill College in Los Altos Hills, Calif., looking for data on de Forest's work while he was employed by the Federal Telegraph Co. The school's archivist proudly showed me Hijiya's doctoral dissertation. The implication was, "Don't waste your time—there's nothing more to be found out." I didn't take his word for that, but there was no doubt in my mind, after skimming the text, that Hijiya had done a prodigious amount of research—not just on Lee de Forest but on other de Forests who had played a role in U.S. history as well.

The writing was dull and pedestrian—typical dissertation stuff. Some of it was mined for Hijiya's earlier book, *J.W. de Forest and the Rise of American Gentility;* other parts form the core of this present book. Fortunately, the material has been transformed: this book is written with style, grace, and sensitivity.

The best parts have, I think, been written anew, and I refer especially to the introduction and the final chapter. Hijiya and I have worked through much of the same material—de Forest's journals, correspondence, and autobiography, and Carneal's semi-authorized biography. In all candor, Hijiya has found more meaning in them than I ever did. Of course, I was looking into de Forest's contributions to technology, and was finding plenty of evidence that they were not as great as de Forest thought they were.

Hijiya, on the other hand, looked for what *drove* de Forest. And in that pursuit he found significance in material I simply skipped over—de Forest's terrible poetry, for instance, a sentimental mishmash of Tennyson and Longfellow; his all-too-revealing comments on his motives and ambitions; his contemptuous dismissal of those who were no longer useful to him; and, of course, his pathetic search for his "Golden Girl," the infinitely malleable female who would fit his conception of the ideal, produce the male child he dearly wanted, but never once have a will or idea of her own. Frankly, in my research, I blanked all this stuff out (while making a mental note to incinerate, in my advanced years, any journals I had ever kept). Hijiya has read every word, with empathy and understanding. In a sense, though, he does the cruelest thing of all: he lets de Forest destroy himself with his own words.

Nevertheless, my visit to the de Forest archives left indelible memories. One was the carelessness with which original documents had been left strewn about on bare wooden shelves, with no apparent attempt at preservation or organization. I was very thankful that the Library of Congress had already microfilmed the essential material. Another shock came when the archivist showed me de Forest's Oscar award, retrieved, he said, from the de Forest home when his widow, then on the verge of poverty, was being taken to a nursing home. Had the archives not intervened, the award would have wound up in the town landfill. So much for fame. I never thought Oscars would corrode so quickly.

Other writers may have described de Forest's inventions better than Hijiya does, although I may be wrong even here. However, no other writer has empathized with, and therefore understood, de Forest as a human being better than Hijiya has.

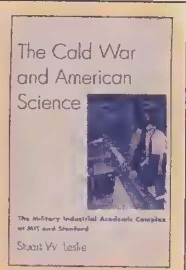
This is, in fact, the best biography of Lee de Forest that I am aware of, and if this is what writing the history of "the religion of technology" means, then I am all for it. But read the book and see for yourself.

Hugh G. J. Aitken is semi-retired from Amherst College in Massachusetts, where he was professor of economics and American studies. He occupies himself by writing about radio history, playing with computers, and operating on the amateur bands (as W1PN). He is the author of Syntony and Spark: The Origins of Radio *and* The Continuous Wave: Technology and American Radio, 1900–1932, *each of which was awarded the Dexter Prize by the Society for the History of Technology.*

Farewell Cold War, we'll miss you

Harvey M. Sapolsky

The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford. *Leslie, Stuart W., Columbia University Press, New York, 1993, $42.*



The Cold War ended easily and well for the West. In the East, too, liberty triumphed as one communist regime after another collapsed from the decay within. For those in the United States, in particular, the war's burdens were quite moderate by its fifth and final decade.

Despite claims to the contrary, we did not live in fear of nuclear incineration. Our young people were not subject to conscription. The cost of maintaining military forces was shrinking in relative terms. And some of our favorite institutions found at least partial support in the war's service. But precisely because the war was so comfortable for us at its end, an appreciation of its purpose and true costs requires a look back at the war's origins and impact on U.S. society.

The author, a historian of science at Johns Hopkins University in Baltimore, attempts to do just that in this study of the relationships among universities, industry, and Government in the formulation of U.S. science policy in the years after World War II. The focus is on the Massachusetts Institute of Technology (MIT) and Stanford University in California, where academic entrepreneurs used military money and Cold War rationales to build technical empires that profoundly shaped the local industrial environment, specifically in what became known as the Route 128 and Silicon Valley areas. Entire disciplines, such as aeronautics, materials science, and electronics (to name just three), were also fundamentally affected.

In chapters that alternate between the two universities, Leslie thoroughly examines the origins, the work being done, and the ties to patrons of such important technical facilities as MIT's Research Laboratory of Electronics, Instrumentation Laboratory (now the independent Draper Laboratory), Lincoln Laboratory, the Laboratory for Nuclear Science and Engineering, and the National Magnet Laboratory, as well as Stanford's Radio Research Laboratory, Linear Accelerator Center, Microwave Laboratory, and Center

Books

for Materials Research.

Leslie's view is that these universities sold their souls to the military, becoming in essence "Pentagon East" and "Pentagon West" for much of the Cold War. In the process, they probably distorted the development of science and engineering in the United States, he believes. Furthermore, these two prestigious schools set an example for other universities, giving the military broad access to, and influence over, some of the nation's top technical talent. The full burdens imposed by this misdirection cannot be calculated, he argues, but are nonetheless real. He hopes that "America can muster the political and moral will to put its science and engineering to work on behalf of a more worthy national agenda and to take a long overdue 'peace dividend'...."

There are problems with this analysis. To begin with, Leslie judges the past too much by the present. Although hardly mentioned in Leslie's work, there were periods of great tension during the Cold War, especially in its early years—precisely when most of the arrangements he so carefully describes were forged. The Cold War ended softly in large part because of the United States' past willingness to mobilize significant elements of its society when necessary. Given the circumstances of the time, the United States needed to develop long-range warning radars as quickly as it could in the early 1950s and, after that, precision guidance systems for ballistic missiles and spacecraft. Of course, the need for these devices seems less urgent as we read today's newspapers.

Furthermore, Leslie notes, but greatly underemphasizes, the ability of scientists to exploit their patrons. Like Willy Sutton, a good scientist has to know where the money is. Having acquired a preference for well-funded research during World War II, a number of academic entrepreneurs were quick to offer their services when the next conflict came along. Much of the capital they gathered in the name of building new weapons went to research projects of their own choosing rather than to weapons as such. The rationales adopted to gain support for research do not have to match the products of that research. As one prominent MIT researcher once put it, "We were the real war profiteers, there is no question about it."

The military was often aware of the exploitation, but could do little about it. For example, senior naval officers attempted but failed to close down the Office of Naval Research, which supported academic science. Air Force generals, too, thought research money would be better spent on bomber procurement, but never managed to eliminate the allocation.

Leslie claims an iron triangle existed among the military, defense firms, and institutions of higher education, which distorted the direction of research. In fact, had he explored executive branch and congressional documents as thoroughly as he did the university files, he might have seen the golden triangle linking congressional committees, research agencies, and academic scientists—a triangle that borrowed heavily from defense allocations to fund a variety of worthy activities, including assistantships for graduate students, research equipment, and many conferences. It is not surprising that the Cold War is missed by some of our nation's leading research universities.

The Cold War and American Science does provide a clear window on an often frenetic, mostly successful period of institution-building at MIT and Stanford. Many of the laboratories created were highly innovative in design. Most had extensive ties with industry. Nearly all were heavily dependent, at least initially, on military funds. Leslie is faithful to the record. He reports their scientific contributions, but believes the costs were too prolonged and too great. One wonders, however, whether he appreciates the context in which the effort took place, or has thought hard enough about its value.

Harvey M. Sapolsky is professor of public policy and organization at MIT and director of its Defense and Arms Control Studies program. He is the author of Science and the Navy: The History of the Office of Naval Research *(Princeton University Press, 1990). He specializes in science and technology policy issues.*

In brief

The Timetables of Technology: A Chronology of the Most Important People and Events in the History of Technology. *Bunch, Bryan, and Hellemans, Alexander, Simon & Schuster, New York, 1993, 490 pp., $35.*

Just how did ancient Egyptian laborers move those heavy stones in building the pyramids? When was the first recorded description of a modern clock powered by a weight? Was it steel frames or the elevator that really made skyscrapers possible? What was Thomas Alva Edison's first patent and why was it unsuccessful?

The answers to these and many more questions are to be found among the 5000 entries in this new reference. Anyone who has ever yearned for a breezily written, comprehensive outline of technological progress need search no more. The book starts about when *Homo erectus* may have begun building dwellings (near what is now Nice, France, about 400 000 years before the casinos) and continuing up to Intel Corp.'s first shipments of the Pentium microprocessor, about a year ago. Along the way, it classifies developments in a dozen or so categories, such as "Architecture and construction," "Communication," "Materials," and "Tools & devices."

The book is also divided up among seven epochs, such as "The Metal Age" (4000 BC to 1000 AD) and "The Electric Age" (1879–1946). Each is introduced with a general overview highlighting the most important developments and innovators of the time. Scattered throughout are capsule descriptions with more information on great inventions and inventors.

The answers to today's pop quiz: limestone blocks for the pyramids were dragged on sledges, probably with liquid poured in front of them for lubrication; contrary to cinematic treatments, rollers or wheels were not used. The first known description of a weight-powered, escapement-regulated clock with balance wheel came from Giovanni de Dondi in 1364. Steel frames made skyscrapers possible; without them, the bottom floors of buildings of even 10 to 16 stories needed concrete walls 6 to 7 meters thick to support the weight. Edison's first patent was for a vote recorder for the U.S. Congress, which went nowhere. A Congressman is said to have told him that legislators wanted to keep voting records imprecise. *Contact: Simon & Schuster, 200 Old Tappan Rd., Old Tappan, NJ, 07675; 800-223-2336 or 201-767-4990; fax, 800-445-6991*

EDITOR: Glenn Zorpette

Recent books

Zen and the Art of the Internet. *Kehoe, Brendan*, Prentice Hall, Englewood Cliffs, N.J., 1994, 240 pp., $24.95.

Running MS-DOS, 6th edition. *Wolverton, Van*, Microsoft Press, Redmond, Wash., 1993, 640 pp., $19.95.

Re-educating the Corporation. *Tobin, Daniel R.*, Oliver Wight Publications, Essex Junction, Vt., 1994 pp. 289, $25.

Microsoft MS-DOS Step by Step. *Catapult Inc.*, Microsoft Press, Redmond, Wash., 1993, 304 pp., $29.95.

Enforcing Restraint: Collective Intervention in Internal Conflicts. *Damrosch, Lori Fisler*, Council on Foreign Relations Press, New York, 1994, 403 pp., $17.95.

Science Advice to the President, 2nd edition. *William T. Golden*, AAAS Press, Washington, D.C., 1994, 340 pp., $29.95.

Deontic Logic in Computer Science. *Meyer, J.J.*, John Wiley & Sons, New York, 1993, 317 pp., $69.95.

Complexification. *Casti, J. L.*, Harper-Collins Publishers, New York, 1994, 336 pp., $25.

The Institute of Microelectronics (IME) in Singapore is actively involved in collaborative research projects with industry, contract research and consultancy projects for industrial clients. Currently, we are seeking experienced professionals for key leadership positions.

IME offers our researchers the opportunity to be at the leading edge of the microelectronics field. As Singapore is the technology hub in the Asia-Pacific region, the successful candidates can look forward to a conducive environment for world-class research and development.

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National University of Singapore
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SENIOR MEMBERS OF TECHNICAL STAFF

■ VLSI Circuit Design & Test

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■ Microelectronic Process Technology

Responsible for applied R&D in silicon-based sensor technology. Job includes sensor design, process simulation and development, testing and packaging. Must have at least five years of experience in sensor development work.

■ Failure Analysis & Reliability

Responsible for co-ordinating and developing new FA and Reliability techniques and methodologies for state-of-the-art microelectronics components and subsystems utilising advanced analytical tools such as STEM, FE SEM/EDX, FTIR, FIB/EBT and SIMS. Must be innovative and flexible with experience in semiconductor technology, packaging and/or reliability testing. Project development and leadership is essential.

■ Advanced Packaging Development Support

Responsible for R&D in packaging technology, supporting advanced package development and solving current packaging problems. Must possess leadership qualities, be innovative and have extensive experience in packaging processes, material characterisation, and reliability testing. Knowledge of FEM stress/thermal/electrical simulations is advantageous.

■ Microelectronic Systems Applications

Responsible for co-ordinating and developing strategic directions in imaging, video and multimedia applications based on international video standards (MPEG, MHEG, H. 261, etc), and leading projects. Must have at least 5 to 10 years of industrial experience in relevant technologies, development methodologies and be well-versed in standards (esp. MPEG). Must be innovative and flexible, good customer-oriented skills. Project management and leadership skills are essential. VLSI and/or board level development and networking experience is highly desirable.

Lead The Team In Creating The Technology Of Tomorrow

Technically speaking

Technophobic texts

Kevin Self

Writers and their publishers are hoping to capitalize on what, for the majority of people, remains an uneasy alliance with computers. Accordingly, the publishing world is bringing forth an array of instructional titles that come right to grips with the prospective reader's self-image with respect to the computer.

Bookshelves reveal that entire series of books are now devoted to coping with computers. Just a few titles from some of the different series indicate how widespread the panic has become: *DOS for Dummies* (IDG Books Worldwide, San Mateo, Calif., US \$16.95); *PCs for Non-Nerds* (New Riders Publishing, Carmel, Ind., \$18.95); *The Complete Idiot's Guide to PCs* (Alpha Books, Carmel, Ind., \$14.95); *Fear Computers No More* (Brady Publishing, New York, \$15.95); and *I Hate DOS, But This Book Makes It Easy!* (Que Corp., Carmel, Ind., \$16.95).

These books assume that the best approach to an intimidating subject is through humor. (One wonders if the teaching of complex vector mathematics could be eased in this way, as well.) *I Hate DOS*, for one, features Top Ten lists. In "Top ten destructive acts committed after file loss," No. 2 is: Fist through monitor (\$13 421, including medical expense and disability). And in "Top ten least popular DOS error messages," No. 10 is: Invalid user, not competent or brain empty.

The books also contain invaluable information for novices: "The computer is about as friendly and helpful as a dead fish," according to *The Complete Idiot's Guide to PCs*. Some even reveal something of the mind of the engineer: *PCs for Non-Nerds* states, "Computer equipment designers try to hide the power switches because they think it's fun to irritate you and also to prevent you from accidentally turning something off."

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Readers' peeves

Several readers have been kind enough to write and tell us about their pet peeves along a more or less technological vein. For Bill Phillips of Anaheim, Calif., his peeve is the difference, if any, between "requirements" and "specifications." On occasion, his project managers have asked him to write one or the other; once he was even asked for "requirement specifications."

Several sources define "requirement" as "that which is called for or demanded; a condition that must be complied with." The second edition of the *Oxford English Dictionary* says that a specification is "a detailed description of the particulars of some projected work in building, engineering, or the like, giving the dimensions, materials, quantities, etc., of the work, together with directions to be followed by the builder or constructor; the document containing this." From this it appears that, although *specification* is more precise, the two terms could be used interchangeably. Using the terms together would be redundant.

Colin McAndrew of AT&T Bell Laboratories, Allentown, Pa., takes issue with the misuse of *alternate* for *alternative*. In his Webster's *New Collegiate Dictionary*, the adjective "alternative" is defined as "offering or expressing a choice," whereas "alternate" is given as "occurring or succeeding by turns." Although the definitions are not mutually exclusive, he sees *alternate* as a poor substitute for *alternative*, because the root meanings of sequentially "taking turns" or a "choice" of simultaneously offered options are distinctive enough to make one or the other more appropriate. Technically Speaking agrees. Although one could alternate between *alternate* and *alternative*, the better choice is generally *alternative*.

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Technically Speaking has noticed a similar problem with the word *kilometer*. Purists adhering to the code of the Système International (SI) (and most dictionaries) insist that the word be accented on the first syllable as kil'-o-me'-ter, but common usage sees it accented on the second as ki-lo'-me-ter.

Mid-word capitals irk Henning Schulzrinne, Granby, Mass., who wonders "who started the atrocious habit of concatenating words with capitals in the middle, as in MagNet5, TableCurve, to cite just two products in the pages of *IEEE Spectrum*. I wonder if it originated in programming languages that could not separate words by underscores (or where the programmer was too lazy to type the extra character)."

He also earns our sympathy when he complains of "a growing trend to capitalize anything in sight....Capitalization is like an exclamation mark or raised volume; overuse diminishes its ability to emphasize."

Spectrum's editorial policy is to avoid the use of more than four capitals in a row. That is, we draw the line somewhere around IEEE. The most obvious example is *Spectrum*'s treatment of acronyms such as Basic (Beginner's All-purpose Symbolic Instruction Code). While most publications would capitalize the entire acronym, *Spectrum* will capitalize only the first letter if it can be pronounced as an "English-sounding" word.

Soothing bromides

A recent article in the business section of the *Dallas Morning News* described the growing popularity of a service that provides electronic copies of résumés to recruiters. In the opening paragraph, the following sentence appeared: "There's a new meaning to that old bromide, 'We're keeping your résumé on file.' " Although Technically Speaking is always on the lookout for helpful advice on job hunting, it was the use of *bromide* that caught our attention.

A bromide is defined as a compound of bromine with an element or organic radical. The element has a bitter, irritating smell—and *bromos* is Greek for stench or stink. Several bromides have medicinal uses, especially potassium bromide, a sedative.

The soothing nature of this compound was slangily equated with a trite, soothing comment. Other bromides include "The check is in the mail," "This won't hurt a bit," "Your request for more funding is being carefully considered," and "That bug will be fixed in the next revision of the software."

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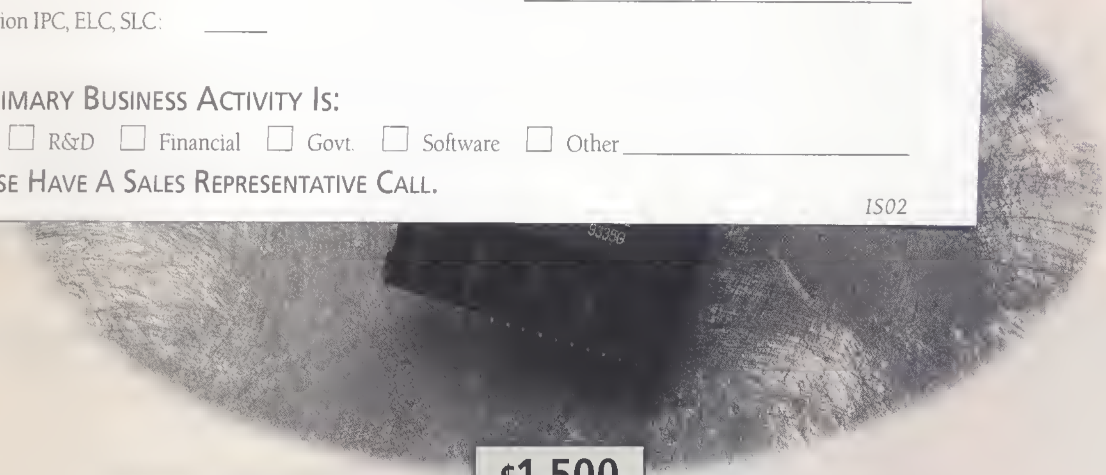

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Kevin Self

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Parallel Computing: Theory and Practice, 2nd edition. *Quinn, Michael J.*, McGraw-Hill, Highstown, N.J., 1994, 446 pp., $63.59.

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Scanning Tunneling Microscopy and Spectroscopy Theory, Techniques, and Applications. Ed. *Bonnell, Dawn A.*, VCH Publishers, New York, 1993, 400 pp., $125.

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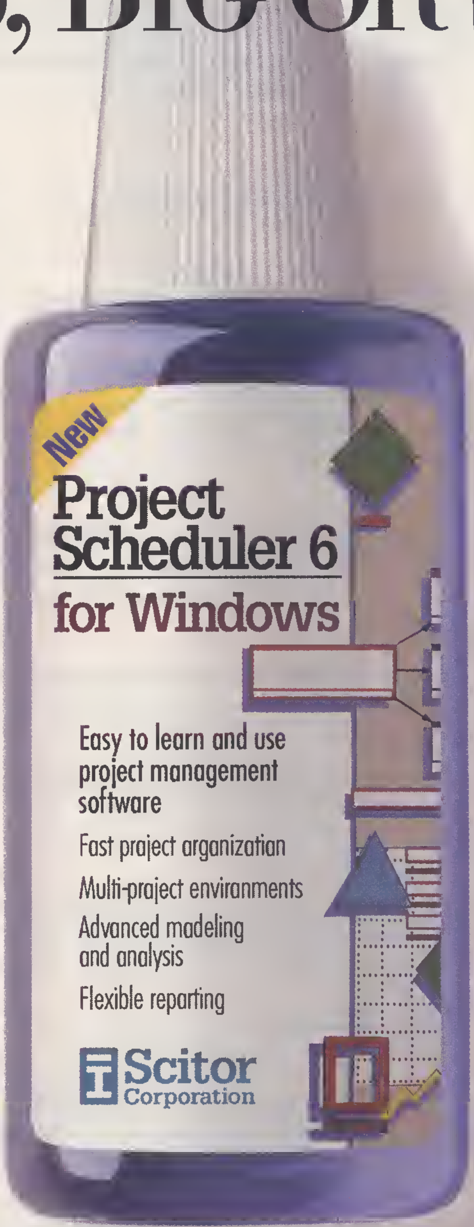

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IBM Dictionary of Computing. Ed. *McDaniel, George,* McGraw-Hill, New York, 1993, 758 pp., $39.50 (cloth), $24.95 (paperback).

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AS/400 Information Engineering. *Porter, John,* McGraw-Hill, New York, 1993, 366 pp., $45.

An Introduction to Reliability & Quality Engineering. *Bentley, John P.,* John Wiley & Sons, New York, 1993, 186 pp., $32.95.

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Foolproof DOS; Foolproof Lotus 1-2-3; Foolproof WordPerfect; Foolproof Windows: 20

(Continued on p. 84F)

Washington watch

Aiming at semiconductors

"We do think there's a difference between computer chips and potato chips," quipped U.S. Vice President Al Gore, unveiling another government-industry technology partnership in March. To underscore the importance of a new semiconductor initiative, at Gore's side were three cabinet officials, the President's science advisor, and leaders of industry.

This new collaboration, though, will not gain much in new money. Rather, "the emphasis will be on aligning existing federal R&D more closely with industry priorities," according to the White House. Four Federal agencies—Commerce, Defense, Energy, and the National Science Foundation—are involved.

Among the planned projects is a center for modeling and simulating integrated circuits, materials, processing, interconnects, and devices. This will be a five-year US $100 million effort involving the Department of Energy's weapons laboratories, with their substantial simulation expertise, and the semiconductor industry.

In addition, the Commerce Department's National Institute of Standards and Technology is creating a $25 million metrology program with the Semiconductor Industry Association (SIA). And later this year, the Administration is to create a Semiconductor Technology Council of leaders in government, industry, and academia to oversee the semiconductor partnership.

SIA president Craig R. Barrett, who is Intel Corp.'s chief operating officer, said the work of the new group will transcend the Sematech chip manufacturing effort (which will continue) to focus on the science and engineering of future chips.

Why is the Government getting more involved? Officials underscored how critical chips are to economic and military security, allowing smarter missiles, better cars, and improved production and services. John Gibbons, the President's science and technology advisor, said there is "no industry more important" to the good of the general public.

Techies in charge of the Pentagon

The two leaders now running the Pentagon will both have scientific and technical backgrounds. Defense Secretary William J. Perry, a mathematician by training and technologist by practice, is to be joined by John M. Deutch as deputy secretary (assuming his confirmation goes through). A chemist, Deutch is a former provost of the Massachusetts Institute of Technology in Cambridge. As the No. 2 man, his job will be to manage day-to-day activities.

Despite a shrinking budget, the science and technology portion of the proposed 1995 defense budget rose slightly, reflecting "the need to maintain the nation's technological superiority," according to the Pentagon. Excluding programs for the Ballistic Missile Defense Organization (BMDO), the budget contains $8.1 billion for core science and technology programs, a real increase of 4 percent over fiscal 1994. BMDO funds would rise from $2.62 billion to $2.98 billion. The Advanced Research Projects Agency would rise from $2.60 billion to $2.66 billion, while projects under the Office of the Secretary

Washington watch

of Defense would increase from $1.20 billion to $1.87 billion. The Clinton administration has also requested that the 1995 Technology Reinvestment Project budget rise to $625 million.

Conversion projects catch on

The first year of competition for $472 million in defense conversion funds from the Government's Technology Reinvestment Project (TRP) came to a virtual close in February when 50 more grants were announced. Altogether, more than 12 000 companies, universities, and government institutions put together proposals—2850 of them—requesting $8.5 billion.

Because of the large number of good proposals, according to a White House press release, some projects were funded from next year's budget, raising the total of Federal matching grants to $605 million. Among the February winners: a project involving Hughes Aircraft Co. and California's Bay Area Rapid Transit to improve train control and double capacity on the same tracks; a consortium effort led by Amerinex Artificial Intelligence, Amherst, Mass., to commercialize NASA's computer vision technology for use in manufacturing and medicine; and a Society of Manufacturing Engineers project to link community colleges with small companies.

Classified algorithm for encryption

Federal policy makers should reconsider the Clipper/Skipjack cryptography scheme, which employs a classified algorithm and Government-held keys as the basis of a new encryption standard, according to a six-page statement by IEEE-United States Activities. "Federal cryptography policy should not fight technological progress by attempting to retain outdated techniques of surveillance at the cost of the reliability and the security of the American information infrastructure," the statement concluded.

The reasons given for issuing the statement included IEEE-USA's concerns that classified algorithms "cannot be proven secure," that individuals seeking to avoid detection would simply choose another cryptography method that can be downloaded from the Internet, and that law enforcement agencies can use other new methods—from vibration-sensing lasers on windows to keyboard-trapping programs. For more information, contact IEEE-USA at 202-785-0017.

Industry positions for professors

To spur implementation of ideas, the National Science Foundation (NSF) is offering grants to professors who wish to spend a few months or more working in industry. Other mechanisms for academia-industry cooperation also exist, and are being promoted by Joseph Bordogna, head of the NSF's engineering directorate. For information about the Grant Opportunities for Academic Liaison with Industry (Goali) program, call 703-306-1234. The new address of the National Science Foundation, which reluctantly moved to its new offices across the Potomac River, is 4201 Wilson Blvd., Arlington, VA 22230. Many NSF reports, announcements, and newsletters are available electronically. For instructions, call 703-306-0214; e-mail, stis@nsf.gov.

Infobahn builders

The White House Information Infrastructure Task Force and corollary groups specializing in issues like privacy have held several meetings to discuss future technological offerings. The goal is to encourage public participation in the creation of the Infobahn (the term now being used around Capitol Hill out of weariness with "information superhighway"). For documents, proceedings, and the like, check out the bulletin board at 202-482-1199.

John A. Adam   Washington Editor

Software reviews

Numbers from figures

Kenneth R. Foster

SigmaScan/Image for Windows
Jandel Scientific Corp. Requires an Intel 80386- or 80486-based personal computer running Microsoft Windows 3.1; a math coprocessor is recommended. The program, excluding the tutorial and sample graphics files, occupies 1.3 MB of hard-disk space. Some features of the program require a 256-color VGA monitor. Purchase price: US $495 (in the United States only).

While many programs will create images that make data visual, SigmaScan/Image for Microsoft Windows does just the opposite. It enables the user to make images yield data. An engineer would use it, for example, to measure distances or image densities on computer graphics images.

SigmaScan/Image packs a broad range of image analysis tools into a user-friendly package. It accepts graphics files in five common formats. The user can adjust the contrast, highlight features of interest using false-color and other transformations, and calibrate a distance scale, zooming in or out without affecting the calibration. Other features make it possible to annotate the figure, perform various measurements, calculate perimeters, areas, or numerous other quantities, and even export the data in various formats to other programs.

To illustrate its capabilities, one sample image shows a man slouching in front of the Leaning Tower of Pisa. The user can measure the angle of the tower, and (using the height of the man as a standard) estimate the height of the tower or the length of its columns. Similarly, an engineer might use the program to measure the variations in density of scanned images of X-ray films.

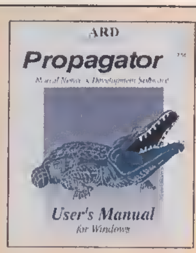
I have found many uses for this program in my own work. For example, one of my students is using Sigma-Scan/Image to digitize video images of human red blood cells being manipulated by electric fields.

The package, though, does have some limitations. On my system (a 33-MHz system using the Intel 80486 microprocessor with 20 MB of memory), scrolling through graphics images is uncomfortably slow. (An inexpensive graphics accelerator card would probably speed things up a lot.) The program operates in a manual-mode only—it is unable to count the number of green squares in an image, for example, or to automatically locate edges. Still, as a tool for unvisualizing data, SigmaScan/Image is remarkably useful. *Contact: Jandel Scientific Corp., 2591 Kerner Blvd., San Rafael, CA 94901; 800-452-6335 (United States only) or 415-453-6700; fax, 415-453-7769; e-mail, sales@jandel.com; or* **circle 100**.

Kenneth R. Foster (F) is associate professor in the department of bioengineering at the University of Pennsylvania in Philadelphia. His e-mail address is foster@eniac.seas.upenn.edu.

Simple neural networks made easy

Philip Kohn



Propagator.
ARD Corp. A convenient package for training, evaluating, and embedding layered feed-forward neural networks in a C program. It is available for the PC running Windows (US $199), Sun workstations ($495), and the Mac ($199). Students get a 25 percent discount.

Before reading this review, readers may gain familiarity with the topic by referring to two IEEE Spectrum *articles: "Neural networks at work," June 1993, pp. 26–32, and "Working with neural networks," July 1993, pp. 46–53. —Ed.*

Even those who have little experience with neural networks will be able to train, test, and embed a common form of neural network in an application program by using Propagator. This development system supports back propagation training of a feed-forward network with up to three hidden layers handling linear, sigmoid, or hyperbolic tangent transfer functions.

The weights can be updated either after each training pattern or after a complete pass through the data. Layers may be fully connected or specified by a file of connections. All the layers, though, must share the same training parameters, such as learning rate or the range of random weights. Noise can be added to the input layer.

Training patterns can be presented either randomly or in sequence. To help the user monitor performance, Propagator provides three graphs that show how the training is progressing and how the errors are distributed across the different outputs. To see how well the network is generalizing on data it has never "seen" in training, a cross-validation database is run during every pass (without updating the weights). A performance graph makes it easy to see when the network has been trained sufficiently, since overtraining will cause an increase in the cross-validation error. And another graph shows the error on each output variable, pinpointing which outputs the network is having trouble predicting. Viewing the error on each output variable as a function of the correct (or target) output is possible, too. Propagator also produces a log file that records all parameters of a training run.

An important missing feature, however, is the lack of a simple way to script a training run. For example, automatically changing the learning rate during training is difficult.

After training, a program called NetGen writes a C function that implements the network. The trained network is compiled and linked with the application program, so that the neural network can easily be viewed as a black box.

The systems manual may be followed easily, but was rarely needed since the user interface was so simple.

Installing Propagator on a SparcStation 2 was straightforward. It proved to run as fast as other training programs run on the same machine.

Propagator is easy to use, and good at what it does. Currently, though, it does not support several architectures and learning algorithms, including Boltzmann machines, recurrent nets with back propagation in time, cascade correlators, and Kohonen networks. Also, the fact that users cannot incorporate their own C functions. will be more of a constraint to some than the limitation to feed-forward neural networks.

Nonetheless, Propagator could serve as a handy tool for exploring back propagation training on problems of interest to many users. *Contact: ARD Corp., 9151 Rumsey Rd., Columbia, MD 21045; 410-997-5600; fax, 410-997-3702; or* **circle 101.**

Philip Kohn is a senior software engineer at the International Computer Science Institute in Berkeley, Calif., where he has designed many neural network training systems. His e-mail address is kohn@icsi.berkeley.edu.

Recent software

Maxwell SI Eminence. An electromagnetic analysis package for high-speed design issues. For leading workstations. US $49 900. *Contact: Ansoft Corp., Four Station Square, Suite 660, Pittsburgh, PA 15219; 412-261-3200; fax, 412-471-9427; or* **circle 102.**

EEs in the boardroom

This small but growing minority of corporate board members can make a big difference to a business's success

The board of directors of Federal Express Corp., in a period of corporate downsizing, was asked to review plans that involved migrating several applications from a pure IBM mainframe environment to open systems—a costly proposition. When faced with approving years of expenditures for the effort, the board looked to its first and only member with an electrical engineering background, Judith L. Estrin.

"They wanted me to confirm that we were on the right track, that we really needed to spend that much money," said Estrin, president and chief executive officer of Network Computing Devices Inc., Mountain View, Calif. "The answer was yes, it is critical to the company."

Estrin, who holds a B. S. degree in mathematics and computer science and an M.S. in electrical engineering, said that in times of hardship, boards tend to squash expenditures they do not understand—like technology—even when it is against their interests to do so. [Like all but one of our interviewees, Estrin is a member of the IEEE.]

WITH CONFIDENCE. The key factor an EE brings to a board is confidence in technology-related decisions, said Jack Lohnes, managing director of board services for Spencer-Stuart & Associates, a national recruiting firm based in Chicago that specializes in identifying potential directors. When making capital investments, which often involve purchases of advanced equipment, a board may often be dealing with millions of dollars of expenditures. "A technical person on the board gives the other board members the confidence to vote for investments," he said.

Estrin agrees. "It is easier for the board to approve certain expenditures [in computer systems]," she said, "when there is a representative on the board who understands technical issues."

At Hitachi Ltd., Tokyo, investment in the company's semiconductor business is one of the most significant issues that faces the board, said Tsugio Makimoto, general manager of the semiconductor and IC division. "The volume of investment is huge, and return on investment is critical," he told *IEEE Spectrum*. "Semiconductor technology innovates fast, and the market changes quickly. Therefore, the decision of investment is critical."

"The other directors seem to expect my advice," he said. "I believe my background is helpful for the decision-making."

In St. Louis, Mo., the Monsanto Co. board turned to director John B. Slaughter, president of Occidental College, Los Angeles, to evaluate its process control division, Fisher Control Systems, to determine whether sensor and instrumentation R&D should be increased. Slaughter, who has B.S. and M.S. degrees in electrical engineering and a Ph.D. in engineering science, earned his research reputation in the theory and applications of control systems. To evaluate the division (now part of Emerson Electric Co.) and make recommendations to the board, he formed a committee of outside experts. "Had I not been available," he said, "they would have had to rely entirely on outsiders, who may have been able to invest more time than I, but the board knew it could trust me to give an objective evaluation."

"You need to have someone you trust to evaluate the product of outsiders," he told *Spectrum*.

In another situation, while on the board of a large corporation (for which he no longer serves), Slaughter found that judgments being made about a corporate expansion were considering only the financial projections, rather than taking into account the significant technical problems that would have to be solved. "I believe I was able to change somewhat the way they approached the issue," Slaughter said, "and that made that decision more successful."

Slaughter feels that, as the only EE currently on IBM Corp.'s board, he has a duty to draw upon his background to assist the board in its oversight role. "I believe I have a responsibility there," he said. In the past, IBM has suffered for its lack of technical expertise on its board of directors, said Winthrop Knowlton, chairman of Knowlton Brothers Inc., New York City, and former head of the center for business and government at Harvard University's Kennedy School in Cambridge, Mass. Others say IBM at various times has had technical expertise on its board, but chose not to use it. "Directors' skills are irrelevant if they are not engaged," Lewis M. Branscomb, former chief scientist of IBM, told *Spectrum*.

E. David Crockett, a partner in Aspen Ventures, Menlo Park, Calif., and a member of the board of Herman Miller Inc., the largest publicly owned U.S. furniture company, based in Zeeland, Mich., has been directly involved in all computer and automation equipment for the company since he joined the board in 1982. "They haven't used outside consultants in all that time," he told *Spectrum*. "They trust what I have to say and, I think, they now have the best computer systems in the industry," which makes them much more competitive. Crockett, who has B.S., M.S., and Ph.D. degrees in electrical engineering, serves on the boards of a number of high-technology companies, and formerly was a member of the board of A.C. Nielsen, Northbrook, Ill.

Having an EE on the board also allows boards to explore issues more fully to question management, rather than rubber-stamping management decisions. Without a technology expert on the board, Knowlton told *Spectrum*, a board often simply accepts what management has to say.

"I invest in small, high-tech companies," Knowlton said, "and their boards are loaded with people who know about science and technology. But when you get up to the boards of the Fortune 500 companies, you usually don't have people who understand technology well. Then you have boards who don't understand how to use technology within the company. They often don't understand the company's products, or even the competitive forces that are shaping the markets for those products."

Another EE, Edward E. David Jr., president of EED Inc., Bedminster, N.J., is on the board of eight high-technology companies, including California Microwave, Compression Labs, and Lord Corp. He said that, while technical decisions are made by company management, not the board, his technical background makes him able to "understand if management is doing something ridiculous."

Sitting on the General Motors Corp. board, said Thomas E. Everhart, president of the California Institute of Technology, Pasadena, allows him to ask about the technology involved in GM vehicles, which serves to inform not only himself, but the rest of the board as well.

"The electric car is an important issue," he told *Spectrum*. "I think my background brings an ability to look at the technical argu-

Tekla S. Perry Senior Editor

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ments and ask the questions that help one to judge whether the technical arguments are correct." Everhart believes the electric car has a key role to play in easing environmental problems, an effort that is currently stymied by the lack of a great battery. "But even though the ideal battery doesn't exist," he said, "a strong argument can be made for working to develop the other parts of the system, because it is a systems problem. It also pushes people to greater efficiencies, which could benefit the whole corporation, not just the electric car."

"I play the catalyst role," Everhart said, noting that other board members have told him they were glad to have him ask certain questions, which helped them understand complex issues important to the corporation.

EEs can also bring lessons from the fast-paced technology industry to the larger, more established companies, which tend to move slower on corporate decisions. Crockett said that Herman Miller had always looked at furniture design as having three- to four-year cycles. By pointing out the typical nine-month design cycle of the electronics industry, Crockett said he was able to help move the company toward much shorter design times. Crockett told *Spectrum* that he has also been able to help the company identify technology trends that affect office furniture design, like computers and communications.

Estrin believes that coming from an entrepreneurial, Silicon Valley company, she brings a different perspective to the Federal Express board.

THE EE MINDSET. Electrical engineers seem to think differently from the executives, financiers, and lawyers who make up most large boards. And this different pattern of thought applies not just to technical issues, but to all the diverse situations faced by boards, to the benefit of those boards.

"I find myself wanting to explore why things are the way they are, to get an analytical understanding of the information being presented," said Branscomb, the former IBM physicist who is now a professor at Harvard University's John F. Kennedy School of Government. Branscomb is on the board of Mobil Corp., Fairfax, Va., and was on the board of General Foods Corp. before it was acquired by Philip Morris Companies Inc. "The business people are more pragmatically interested in drawing conclusions from the *what*, rather than the *why*."

College president Slaughter said that he treats the issues that come before the boards on which he serves like engineering problems. "I may be less likely than the other directors to let emotions get in the way," he noted.

"An engineer has learned to depend on data to analyze things before drawing conclusions," concurred Erich Bloch, a distinguished fellow at the Council on Competitiveness in Washington, D.C., "and not to act on emotion and hearsay. He brings that approach to decisions before the board."

Network Computing Devices Inc.

JUDITH L. ESTRIN
President and chief executive officer, Network Computing Devices Inc., Mountain View, Calif.

Boards include: Federal Express

"It is easier for the board to approve certain expenditures when there is a representative on the board who understands technical issues."

Occidental College

JOHN B. SLAUGHTER
President, Occidental College, Los Angeles

Boards include:
Atlantic Richfield
Avery Denison
IBM
Monsanto
Northrop

"I may be less likely than the other directors to let emotions get in the way."

Harvard University

LEWIS M. BRANSCOMB
Professor, John F. Kennedy School of Government, Harvard University, Cambridge, Mass.

Boards include: Mobil

"Directors' skills are irrelevant if they are not engaged."

Bloch, former director of the National Science Foundation, Arlington, Va., has a B.S. in electrical engineering and serves on the boards of Motorola Inc., Schaumburg, Ill., and Convex Computer Corp., Richardson, Texas.

One other strength of the engineering thought process was pointed out by H. Rodney Sharp III, the only electrical engineer on the board of E. I. du Pont de Nemours and Co. (DuPont Co.), Wilmington, Del. "Coming from the computer business," he said, "concepts like flexibility, keeping your options open, tend to be important to me. In engineering something, you are always looking forward to the time when you may change this thing, and you try to make it as easy as possible to do that. I apply this to decisions coming before the board and try to avoid locking ourselves in to one position."

"The way I go about solving problems comes from my engineering training," Network Computing Devices' Estrin said. "As opposed to looking at one overwhelming problem, I tend to break it down and look at the pieces."

A key attribute of the engineering mindset, it seems, is a desire to get involved in the details of an issue. "An engineer needs to make sure there is a logical construct behind the overall design," Caltech president Everhart said, "and that the details agree with the overall picture."

Not all engineers, regardless of their expertise and experience, are suited to serve as board members, though, because while it is appropriate for boards to consider some of the details behind a decision, it is not appropriate to go back to the original data and redo the work of management.

"You do have to be careful, when you are looking at the detail, not to micromanage," Everhart said.

"You don't get to do the work," Estrin said. "You are there five times a year, and you have to trust that the people in the company have already done the analysis, are presenting you with a conclusion, and all you can do is quickly decide whether or not to question that conclusion. Sometimes it is hard for an engineer to back off and let others make the decisions."

QUID PRO QUO. While boards may benefit from adding a technologist to their ranks, EEs say they benefit, too, from their service on corporate boards. Sharp enjoys his opportunities to visit DuPont's various manufacturing plants. "Because I can demonstrate a little technical understanding of what people are doing," he said, "I can build a more interesting relationship with some of the people in the plants." This helps the company, by making the board seem less distant from employees, and also broadens Sharp's knowledge.

Estrin admires and hopes she is learning from Federal Express's success at maintaining its original values of customer service while growing so large. She also finds intriguing the analogies between Federal Express's business and the computer industry. "I listen to discussions about competing against UPS or Airborne, and it is similar to our industry," she said. "There is always someone in the marketplace who has critical mass, and someone else who bombs the price to try to get the business."

Intriguing also is how Occidental College's Slaughter finds the board deliberations at Avery Denison, Pasadena, Calif. "It is a very well-managed company, and I've learned a great deal about how you manage an international corporation," he said.

For venture capitalist Crockett, the Herman Miller board is a contrast to the boards of the many small entrepreneurial high-tech companies on which he also serves. While technical boards look at issues homoge-

Jon Brenneis

E. DAVID CROCKETT
Partner, Aspen Ventures, Menlo Park, Calif.

Boards include: Herman Miller

"They trust what I have to say and, I think, they now have the best computer systems in the industry."

neously, talk in shorthand, and make fast decisions, he said, the "Herman Miller board is very diverse—the director of the Smithsonian Institution's National Portrait Gallery, an orthopedic surgeon, a former member of the Thatcher cabinet. So we have had to learn to listen to each other. We take longer to make decisions, because everybody has to get in tune with what the other people are saying. But it is well worth the extra time spent."

Crockett also credits his experience on the Herman Miller board with teaching him the importance of a philosophy of leadership.

Everhart sees his position on the GM board as a form of national service. "For every car that is assembled, there are 10 jobs provided outside the company," he said. "A prosperous automobile company brings prosperity to the United States." He also takes seriously the importance of protecting the environment, and chairs the board's public policy committee that deals with such issues.

Also interested in the environmental issues that must be addressed on the boards on which he serves, Slaughter participates in Atlantic Richfield Co.'s Environmental Health and Safety Committee. He believes he has another important role as well—promoting corporate diversity—and he uses his board positions to do so.

California Institute of Technology

THOMAS E. EVERHART
President, California Institute of Technology, Pasadena

Boards include: General Motors

"The electric car is an important issue. I think my background brings an ability to look at the technical arguments."

THE BACK DOOR. While corporations today can live or die depending on how they apply technology to their businesses, the typical director of a Fortune 500 or other large, diverse corporation is a chief executive officer of another large company, or comes from a legal, financial, or political background. Electrical engineers and other technologists have slipped into corporate board ranks, thanks to their executive or political experience, family connections, or, sometimes, because a board needed to add a minority group member or a woman.

"I have seldom had anyone say, 'Find a technical person for my board,'" said SpencerStuart's Lohnes.

Estrin was selected for the Federal Express board in 1989, she told *Spectrum* frankly, because the board was seeking to add a woman. "Every time someone calls me to be on a board, I know exactly why they are calling. My name came to the top of a list because they want a woman." Estrin gives Federal Express CEO Fred Smith credit, however, for seeking a woman who could add value to the board in other ways, and she believes her technical and entrepreneurial background did contribute to her selection.

Sharp was put on the DuPont board in 1981 to succeed his father, in line with the company's tradition of seating descendants of founder Eleuthère Irenéé du Pont on the board. Sharp, who has a B.S. in electrical engineering, had an edge over other family members because most of his career had been spent at Du Pont (he is now retired). He told *Spectrum* that his engineering education and experience with the company's computer operations were probably irrelevant to his being selected.

Slaughter's board seats—on IBM, Atlantic Richfield, Northrop, Monsanto, and Avery Denison—are impressive and diverse. On most, he believes, he is the only electrical engineer. While he said that many boards in recruiting him mentioned that his technical background would bring them an important additional perspective, Slaughter thinks he is so sought after because of his political connections (he was director of the U.S. National Science Foundation under President Jimmy Carter), his managerial experience as a college president, and because, as an African-American, he brings a diversity sought by many boards.

When companies do realize that their boards would benefit from having someone with a solid technical perspective, they think first of someone from a university, like Slaughter, or a chief scientist, who often is a physicist by training, said Michael Maccoby, president of the Maccoby Group, Washington, D.C., which studies corporate organizational behavior. Branscomb, for example, was recruited to the boards of General Foods and Mobil because the companies were concerned with oversight of their research investments, and wanted to balance the skills of the other directors with someone experienced in managing industrial science and technology.

Everhart is one EE who does believe he was recruited to a large corporate board specifically because of his technical background. General Motors is one of the few corporations that maintains a science advisory committee as a permanent adjunct to the board for consultations on technical issues. In 1980 he was recruited to that committee for his knowledge of semiconductors and technology policy (he was then dean of engineering at Cornell University, in Ithaca, N.Y.). Nine years later he was brought onto the GM corporate board to represent science and engineering, succeeding Charles Townes, the inventor of the maser, who now teaches physics at the University of California at Berkeley. Everhart has an engineering Ph.D. and earlier in his career specialized in research on microwave tubes and electron beam applications.

"Most boards try for diversity in their members," Everhart told *Spectrum*. "General Motors believes that having someone knowledgeable about science is valuable."

The situation in Europe and Japan is similar, although the board structures differ. For one, banks own sizable blocks of shares, and bankers often end up on boards. And firms often own shares in each other.

In Europe, the boards of companies are often dominated by corporate management,

YASUTSUGU TAKEDA
Senior executive managing director, Hitachi Ltd., Tokyo

Boards include: Hitachi

His senior managerial experience as well as his technical training earned him a place on the board.

Linda Geppert

although a relatively recent trend there is for companies to have two boards, a managing board made up of insiders and another, similar to U.S. boards today, made up of outside directors, said Richard Johnson, an assistant professor of management at the University of Missouri, in Columbia, who researches board behavior. While technical people may serve on a European board, they reach that position because they climbed the management ranks of a company, not because of their technical training.

At Munich-based Siemens AG, for example, according to German Stock Corporation Law, the company has both supervisory and managing boards that are fully separate. Half the members of the supervisory board are elected by the shareholders, and half by employees. The managing board currently has four members trained in electrical engineering, Hans Bauer, Volker Jung, Horst Langer, and Günter Wilhelm. The managing board elects the corporate executive committee, and it is this committee that actually manages the company.

In Japan, boards are dominated by insiders or members of sibling companies from the same family of companies—called *keiretsu*— tied together by cross-ownership of shares. Since each *keiretsu* is linked to at least one bank, representatives from the banking community are also typical on boards, Johnson said. Engineers here, too, may climb the managerial ranks to a board seat.

Trained as an electrical engineer, Yasutsugu Takeda, senior executive managing director and a member of the Hitachi board, told *Spectrum* that while he was a researcher in optoelectronics early in his career, he pioneered the development of several commercial products and gained a reputation as a manager. It was his senior managerial experience as well as his technical training that earned him a place on the board.

Also on the Hitachi board, Makimoto, who earned his M.S. and Ph.D. in electrical engineering, told *Spectrum* that while his management position led to his spot on the board, his technical experience in semiconductor engineering seems to be appreciated as well.

Currently, though no statistics exist, it appears that the number of EEs on corporate boards in the United States, excluding the boards of focused, entrepreneurial high-technology companies, is small. Europe may have even fewer people with technical backgrounds on its boards, Lohnes said, though again, there are no hard statistics. Japan's boards have the largest technical cadre because companies recruit many of their board members internally, and because, for some companies, an overwhelming proportion of initial hires come with technical degrees, even if that training is never applied. At Hitachi, for example, 80 percent of the people hired by the company are engineers, Takeda said.

A TREND? Only within the last 10 years or so, spurred by the increased pervasiveness of information and communications technology in all industries, has technology become such a critical component of corporate operations. "Even a clothing manufacturer," said SpencerStuart's Lohnes, "relies on information and communications systems for distribution planning, which is key to the profitability of such an organization." Perhaps the number of EEs on boards is poised for a surge, as the current ranks of director-EEs demonstrate that they are, indeed, a competitive tool.

Will corporate boards begin consciously seeking board members with technical skills? Only time will tell.

"These days the fad is bringing in people who run pension funds and mutual funds, to represent shareholders," Knowlton said. "But they don't generally have the [necessary] technical expertise and many are under short-term pressure to perform.

"Getting in some good technologists would be to the benefit of corporate management," he continued. "Such people would have a sense of how long it takes to develop products. They would affect the entire rhythm of corporate life."

TO PROBE FURTHER. The evolving role of corporate boards, from a clique of the chief executive's friends to the strong and diverse independent board, is discussed in *Pawns or Potentates—the reality of America's corporate boards,* by Jay W. Lorsch with Elizabeth McIver (Harvard Business School Press, Boston, 1989).

The history of U.S. boards, and the difference in typical structures among U.S., European, and Japanese boards is discussed in "Corporate Governance Survey," *The Economist,* Jan. 29, 1994. Similar issues are addressed in GAO report GAO/GGD-93-124, "Competitiveness Issues: The Business Environment in the United States, Japan, and Germany," available from the U.S. General Accounting Office, Box 6015, Gaithersburg, MD 20864-6015; 202-512-6000; fax, 301-258-4066. ◆

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best routes available, and they were hooked. How else could they routinely find the fastest and most efficient route through 3000 square kilometers of central Florida?

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W. Clay Collier and Richard J. Weiland
SEI Information Technology

General Motors Corp.

Route guidance systems tie in automotive electronics and satellite communications with roadway databases. Here a driver inputs a destination, views the route on a map, and then is guided by audible turn-by-turn instructions.

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YASUTSUGU TAKEDA
Senior executive managing directo[r]
Hitachi Ltd., Toky[o]

Boards include: Hitachi

His senior manage[rial] experience as wel[l as] his technical train[ing] earned him a plac[e] on the board.

Linda Geppert

although a relatively recent trend there is for companies to have two boards, a managing board made up of insiders and another, similar to U.S. boards today, made up of outside directors, said Richard Johnson, an assistant professor of management at the University of Missouri, in Columbia, who researches board behavior. While technical people may serve on a European board, they reach that position because they climbed the management ranks of a company, not because of their technical training.

At Munich-based Siemens AG, for example, according to German Stock Corporation Law, the company has both supervisory and managing boards that are fully separate. Half the members of the supervisory board are elected by the shareholders, and half by employees. The managing board currently has four members trained in electrical engineering, Hans Bauer, Volker Jung, Horst Langer, and Günter Wilhelm. The managing board elects the corporate executive committee, and it is this committee that actually manages the company.

In Japan, boards are dominated by insiders or members of sibling companies from the same family of companies—called *keiretsu*— tied together by cross-ownership of shares. Since each *keiretsu* is linked to at least one bank, representatives from the banking community are also typical on boards, Johnson said. Engineers here, too, may climb the managerial ranks to a board seat.

Trained as an electrical engineer, Yasutsugu Takeda, senior executive managing director and a member of the Hitachi board, told *Spectrum* that while he was a researcher in optoelectronics early in his career, he pioneered the development of several commercial products and gained a reputation as a manager. It was his senior managerial experience as well as his technical training that earned him a place on the board.

Also on the Hitachi board, Makimoto, who earned his M.S. and Ph.D. in electrical engineering, told *Spectrum* that while his management position led to his spot on the board, his technical experience in semiconductor engineering seems to be appreciated as well.

Currently, though no statistics exist, it appears that the number of EEs on corporate boards in the United States, excluding the boards of focused, entrepreneurial high-technology companies, is small. Europe may have even fewer people with technical backgrounds on its boards, Lohnes said, though again, there are no hard statistics. Japan's boards have the largest technical cadre because companies recruit many of their board members internally, and because, for some companies, an overwhelming proportion of initial hires come with technical degrees, even if that training is never applied. At Hitachi, for example, 80 percent of the people hired by the company are engineers, Takeda said.

A TREND? Only within the last 10 years or so, spurred by the increased pervasiveness of information and communications technology in all industries, has technology become such a critical component of corporate operations. "Even a clothing manufacturer," said SpencerStuart's Lohnes, "relies on information and communications systems for distribution planning, which is key to the profitability of such an organization." Perhaps the number of EEs on boards is poised for a surge, as the current ranks of director-EEs demonstrate that they are, indeed, a competitive tool.

Will corporate boards begin consciously seeking board members with technical skills? Only time will tell.

"These days the fad is bringing in people who run pension funds and mutual funds, to represent shareholders," Knowlton said. "But they don't generally have the [necessary] technical expertise and many are under short-term pressure to perform.

"Getting in some good technologists would be to the benefit of corporate management," he continued. "Such people would have a sense of how long it takes to develop products. They would affect the entire rhythm of corporate life."

TO PROBE FURTHER. The evolving role of corporate boards, from a clique of the chief executive's friends to the strong and diverse independent board, is discussed in *Pawns or Potentates—the reality of America's corporate boards,* by Jay W. Lorsch with Elizabeth McIver (Harvard Business School Press, Boston, 1989).

The history of U.S. boards, and the difference in typical structures among U.S., European, and Japanese boards is discussed in "Corporate Governance Survey," *The Economist,* Jan. 29, 1994. Similar issues are addressed in GAO report GAO/GGD-93-124, "Competitiveness Issues: The Business Environment in the United States, Japan, and Germany," available from the U.S. General Accounting Office, Box 6015, Gaithersburg, MD 20864-6015; 202-512-6000; fax, 301-258-4066. ◆

Smart cars, smart highways

The latest electronics for automobiles and roadways herald far fewer traffic jams, greater safety, and perhaps even a decline in pollution

No wonder the managers of the multimillion-dollar TravTek project had trouble getting their systems back. The motorists testing the units had enjoyed being guided along the best routes available, and they were hooked. How else could they routinely find the fastest and most efficient route through 3000 square kilometers of central Florida?

Those drivers got a taste of what technology here and now can do to unclog the transportation network for private vehicles as well as trucks, buses, and even trains. Anyone who drives to work, goes to a shopping mall, or rides a school bus could soon find electronics making traffic safer and the journey speedier. In Japan, in fact, many drivers today rely on route guidance from the 400 000 or so systems already sold there.

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Route guidance systems tie in automotive electronics and satellite communications with roadway databases. Here a driver inputs a destination, views the route on a map, and then is guided by audible turn-by-turn instructions.

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ways, governments are promoting these ideas as a way of keeping their nations competitive in the world market. Advocates see such proposals as a means of improving safety and easing traffic delays, thus improving commuters' productivity and perhaps alleviating pollution at the same time.

The market is expected to be sizable. IVHS America, a Washington, D.C.–based association of 500 organizations representing industry, government, and universities, estimates that more than $200 billion will be spent on IVHS in the United States within 20 years. Many defense contractors see this as a lucrative field, an outlet for expertise in such areas as sensors and communications.

In 1991, the U.S. government committed itself to IVHS by allocating $659 million over six years under the Intermodal Surface Transportation Efficiency Act (Istea). The most important piece of transportation law since the Interstate Highway Act in 1956, Istea represents a dramatic turn for infrastructure policy.

"In the past we've solved transportation problems by simply building new roads," said Gary Euler, the Federal Highway Administration's chief of program management and systems engineering. "But that's not as acceptable or possible as it once was." By recognizing that reality, Istea "substantially changed" U.S. surface transportation development.

A huge undertaking, IVHS comprises six areas of application. Three—traveler information, traffic management, and vehicle control—have a broad technical aim. The three others group targeted sectors: public transportation, commercial vehicles, and rural transportation.

TRAVELER INFORMATION. The area with the most near-term applications is traveler information systems, which are largely self-contained within vehicles and thus require little or no supporting infrastructure. Toyota was the first to market with digital map-display systems, in 1987. Four years later, Japan's largest automaker added route guidance, so the map system could calculate routes and display paths to drivers. In 1992, voice guidance was implemented.

The current Toyota navigation product line, which tops out at more than US $8000, includes such components as a 14-cm liquid crystal display (LCD) with an infrared touch screen that supports television, navigation, a rear-view camera, telephone, and radio controls. There are front and back receivers for satellite data from the global positioning system (GPS), in addition to a geomagnetic compass and steering sensors. A CD-ROM changer handles the 4-gigabit map database (40 percent voice), which includes most of Japan divided into eight regions, each stored on a separate CD-ROM. The maps contain intersection illustrations and stored voice data for each intersection. Most Japanese automakers, including Nissan, Honda, and Mitsubishi, now offer digital map systems using a standard database. Already, several hundred thousand basic navigation systems capable of displaying a vehicle's location on a map have been sold domestically [see "Making transportation smarter in Japan"].

In the United States, General Motors Corp. unveiled the country's first production navigation system in January at the Detroit Auto Show. The Oldsmobile Naviga-

Making transportation smarter in Japan

Densely populated Japan has long had a keen interest in smart cars and smart highways. During the 1970s, economic prosperity brought more cars and congestion to Japan's roads. The dream of the Intelligent Vehicle Highway System (IVHS) was hatched with a 1973–79 project by the Ministry of International Trade and Industry (MITI).

That first effort has had a constant flow of successors.The commercial market is already working to make individual cars smarter—a precursor of a more integrated IVHS system. Currently, several hundred thousand vehicles in Japan are equipped with self-contained navigation systems, according to Akira Onaka, executive managing director of the Japan Digital Road Map Association. These systems can be added to existing cars or bought already installed in new vehicles. The majority rely on a standardized digital road map database completed by the association.

'BIT' MAPS. Some cultural factors have encouraged drivers to adopt digital maps. Japanese cities are intrinsically hard to navigate. An address is defined in terms of city name, area name, block number, estate number, and parcel number, so that building numbers are not always consecutive.

Moreover, cities in Japan develop as belts or large areas, and it is hard to tell where one ends and another begins. Because of the urban sprawl, single-sheet maps are not sufficient for guiding a driver; Japanese motorists usually carry road map books with many pages. Another cultural trait, noted by Dnaka, that encourages the use of digital car maps is written Japanese; the meanings of its symbolic characters can be recognized at a glance.

In 1988, the Japanese Digital Road Map Association was created through a joint proposal by the Ministry of Construction, universities, and private companies. The 82 member companies are drawn from many industries, particularly automotive, electronics and communications, and mapping and surveying. They agreed on a grid network defining roads as links between nodes, in turn defined by x and y coordinates numbered from 0 to 10 000 for a swatch of approximately 10 square kilometers. The system will have meter-level precision.

Japan has about 1.1 million kilometers of roads; some 30 000 km are constructed or reconstructed each year. Already, the entire nation has been mapped digitally to a scale of at least 1:50 000. As of March 1993, half of Japan was mapped to a scale of 1:25 000, and the goal, Dnaka wrote in a recent IVHS America paper, is to bring that same resolution to the entire country within five years. For pinpoint navigation to specific locations on the smallest of roads, he believes, maps would need a scale of 1:10 000.

Although the road data is standard, information about hotels, restaurants, and so on serves to distinguish digital map products in the competitive commercial market. For safety and ease of use, car navigation systems do not offer full functions during driving.

Map publishers, who had been maintaining independent road databases, have switched to the standard digital database for reasons of both economy and its future adaptability to the Vehicle Information and Communication System (VICS). This project will integrate smart cars into a network—an advantage not only for central traffic monitoring but also for the timely dissemination of reports to individual motorists. This would allow traffic conditions to determine the quickest routes between two points.

TOKYO DEMO. Stimulated in part by international IVHS activities, some projects were recently launched in Japan. The five current IVHS projects are supported by five government agencies: MITI, the National Police Agency, and the ministries of Post and Telecommunications, Construction, and Transportation.

VICS was created to promote the early implementation of systems, developed in the late 1980s, that use a standard digital database for positioning. Around 200 organizations are supporting the project, including the Ministry of Posts and Telecommunications, the Ministry of Construction, and the police agency. The goal is to tell drivers about road traffic by making efficient use of the radio wave spectrum. A central information system, collecting data on traffic from existing sources, will disseminate traffic reports by various media: optical and radio beacons at specific locations in roadways; FM radio; and teleterminals. Users will be able to access information in real time according to their preferred medium. Demonstrations have been proceeding in the center of Tokyo since June 1993. Last November, more than 500 people, including government ministers, took part in a demonstration using 45 cars. The project's next goal is commercialization and deployment.

The other main projects—the Advanced Road Transportation System, the Advanced Safety Vehicle, and the Super Smart Vehicle System—emphasize long-term research, with implementation not expected until the 2000s or 2010s. The Universal Traffic Management System (UTMS) aims at the early implementation of the ATMS system, with concurrent research and development in the vast area.

Intelligent coordination between vehicles and the road infrastructure is the goal of the advanced road transportation project, which is supported by the Ministry of Construction. The system is supposed to be fully realized in the first decade of the next century. Key areas are road monitoring, collision warning, automated toll collection, and advanced freight

Siemens AG

In Oakland County in Michigan, the traffic operations center of the Fast-Trac project has reduced commuting times by means of interactive communications and road sensors.

tion/Information System, whose database resides on a PCMCIA card, will become available in the spring on Olds Eighty-Eight LSS sedans [Fig. 1]. Initial deliveries in California will be followed by a staged nationwide rollout. The $2000 add-on, based on a Motorola 68EC020 processor, uses dead reckoning and GPS navigation and offers displayed and spoken "turn by turn" driving instructions. On its 10-cm active-matrix color LCD screen, it can also display local points of interest and route drivers to the nearest hotel or gas station. The unit swivels and can easily be removed for safekeeping.

The Oldsmobile system was developed at Zexel USA using a map database by Navigation Technologies, Sunnyvale, Calif., and software developed by SEI Information Technology [see "Finding your way"]. It follows in the footsteps of a $12 million technical and marketing demonstration sponsored by General Motors, the Federal Highway Administration, the American Automobile Association (AAA), the state of Florida, and the city of Orlando. TravTek, one of the most ambitious traveler information field tests, concluded last year. One hundred Oldsmobiles were each equipped with one of two types of information systems: either a basic version with electronic "Yellow Pages" information on hotels, restaurants, and points of interest, or a more elaborate version with a route guidance system that could calculate the most direct routes (or various alternatives) to any address within 3000 square kilometers of roadway in the greater Orlando area. With a 4800-baud communications link and a data radio, drivers could also receive information on traffic, weather, and such special events as concerts or ball games. A computer-synthesized voice could issue instructions about when to turn and give traffic updates. The car's system was based on two computers, each with an Intel 80386 processor and 4 MB of RAM.

Three-quarters of these cars went to Avis Rent A Car, which rented them to AAA members for periods averaging one week; the balance went to Orlando residents for longer trials. Users rated overall performance on a scale of 1 (poor) to 6 (excellent). The cars with route guidance systems consistently scored highest, with an average rating of 5.2.

"Tourists found them fun and very helpful, and business people were able to keep more appointments each day," said Don Gordon, TravTek project manager at the AAA. "Older drivers said the systems helped them drive at night because they didn't have to worry about reading street names on the corner. No one wanted to give them up."

In California a similar study gave further proof of the commercial viability of navigation systems. There, a Zexel-developed route guidance system—an early version of the one Oldsmobile would later buy—was installed in several rental cars operated by Avis at the San Jose airport. The product's popularity was one factor in GM's decision to move forward with the Oldsmobile system. (Avis plans to include the system in 100 of its Oldsmobiles in its Bay Area fleet.) The system will be introduced nationwide in tandem with the

operations. There are three near-term Advanced Road Transportation System experiments. One assesses high-speed, real-time communication (at 1.5 and 2.6 GHz) between the road system and vehicles using a leaky coaxial cable; variables include cable height and vehicle speed. Another experiment is to use variable lighting on roads to make drivers more aware of potential hazards, such as passing vehicles, road alignments, and intersections. A third experiment is investigating control systems to maintain headway distance between vehicles and the margin between vehicles and road facilities.

The Advanced Safety Vehicle project, proposed by the Ministry of Transportation for fiscal 1995, is to design a prototype that will be produced by car manufacturers—a guiding principle. Its vehicle-safety technologies focus on four areas: the reduction of driver workload in normal situations; the avoidance of accidents through warning and automated operations; the reduction of damage in collisions; and timely reporting and dissemination of information to prevent disasters from growing.

MITI promoted the Super Smart Vehicle System, a three-year project that ended in fiscal 1992. Government, carmakers, electronics manufacturers, academia, and nonprofit organizations collaborated in seven working groups. The result was the formulation of an R&D plan for IVHS development, to be realized in the 2010s. The plan includes vehicle-to-vehicle communication, intelligent street driving, and automated highway driving.

BETTER FOR BUSES. In Japan, the National Police Agency regulates traffic management. It amazed the IVHS community by adopting two new policies. The first was to furnish traffic information from the Tokyo Metropolitan Police Department to terminals in homes, offices, and cars by traditional or cellular phone links. The second was the development of a new type of optical vehicle detector and the proposed UTMS.

Already being installed, the optical detectors project near-infrared light on the road and monitor its reflection from the vehicles and pavement. Besides assessing traffic flow at speeds up to 120 km/h, the system communicates information to the vehicles. The National Police Agency and Mitsubishi Electric Corp. note that the detector is cheaper than alternatives, so it may be more extensively employed—for example, to help control traffic lights. After a successful demonstration in 1992, the police agency hopes to install 5000 of them every year.

The Universal Traffic Management System project has several components and relies heavily on a central integrated traffic control system, according to a recent paper by Ken-ichi Aoyama, assistant director of the police agency's Traffic Management and Control Division in Tokyo. Besides helping car drivers by alerting them to traffic and accidents, the system will improve the punctuality of public transportation. By using tracking and signal control, for instance, buses could spend less time moving through intersections.

With the exception of MITI's project in the 1970s, most of the financial support for Japan's IVHS work has come from the private sector. Under such conditions, further advances to implement the infrastructure for IVHS will be difficult. Fortunately, with the demonstration of recent technologies showing the advantages of practical use, the public sector's attitude may be changing. —*Sadao Takaba*

The author is a professor at the University of Tokyo's Institute of Industrial Science. He is chairman of the Tokyo Chapter of the IEEE Vehicular Technology Society and serves as an advisor for the VICS and the Universal Traffic Management System projects.

expansion of the navigable database on which it depends. "It was just a matter of timing, of price meeting market demand," said Mark Krage, section manager of GM's Manufacturing Diagnostics and Control Division. The eventual aim is to offer the system at approximately the cost of an air conditioner.

The next generation of field tests—Advance, combining traveler information, route guidance, and traffic management technologies in an effort to better understand and streamline traffic patterns in the greater Chicago area—is to start later this year on some of the busiest roads in the United States. A cooperative effort by Motorola, the Federal Highway Administration, the Illinois Department of Transportation, a consortium of Illinois universities, and several automakers, Advance will equip several thousand vehicles with route guidance systems that use up-to-date traffic information to calculate time-saving routes. These test vehicles will not only receive information but also double as traffic probes, reporting their travel speeds and locations back to a traffic management center that will incorporate the data into traffic reports.

TRAFFIC MANAGEMENT. Traveler information systems optimize an individual's journey; traffic management systems aim to make an entire transportation system more efficient through such means as adaptive traffic-light timing, electronic warning signs, and automated toll collection. One of the largest field tests is taking place in Oakland County, Mich., just outside Detroit, the heart of the U.S. automobile industry [see photo on previous page].

Ironically, this area had the worst possible ratings for intersection tie-ups—a grade of F, according to Dick Beaubien, transportation director for Hubbell, Roth & Clark, a Michigan consulting engineering firm that studied the problem. (The rating indicates that drivers were delayed more than one minute at each intersection and would in all likelihood have to idle through more than one signal cycle to pass the offending traffic light.) To alleviate the problem by widening the roads would cost $1 billion, estimated the Oakland County Road Commission, yet its budget of $100 million had only 10 percent allocated to physical road improvements. As an alternative, the commission won approval to attempt an IVHS solution, Fast-Trac.

The commission targeted 28 of its most gridlocked intersections in the city of Troy. TV cameras have been placed at each, and AutoScope, an image-processing system developed at the University of Minnesota, collects and analyzes flow rates and the length of queues. The results are downloaded to a traffic-signal control computer running an Australian-developed system called the Sydney Coordinated Adaptive Traffic System (Scats). Scats adjusts the timing of lights to optimize traffic flow.

Since the system was introduced in June 1992, the 50 000 and more commuters on the county's busiest artery, Rochester Road, have seen peak travel times dip by 15–20 percent. Not a single road had to be torn up or closed down for its deployment. "The more sophisticated systems require no pavement adjustment and are monitored only by exception," said Beaubien, who helped coordinate the project. "Everything is above ground, easy to get to, easy to fix."

Encouraged by the results, the Federal Highway Administration agreed to support the incorporation of a further 95 Oakland County intersections into Fast-Trac. In addition, developers plan to introduce Siemens Ali-Scout route guidance systems early next year. Unlike the autonomous route guidance provided by TravTek and Advance, Ali-Scout accepts routing requests from vehicles via roadside infrared beacons, calculates routes centrally, and beams them back. Although centrally controlled systems require less sophisticated gear inside cars, the cost of the required infrastructure equipment can be significant.

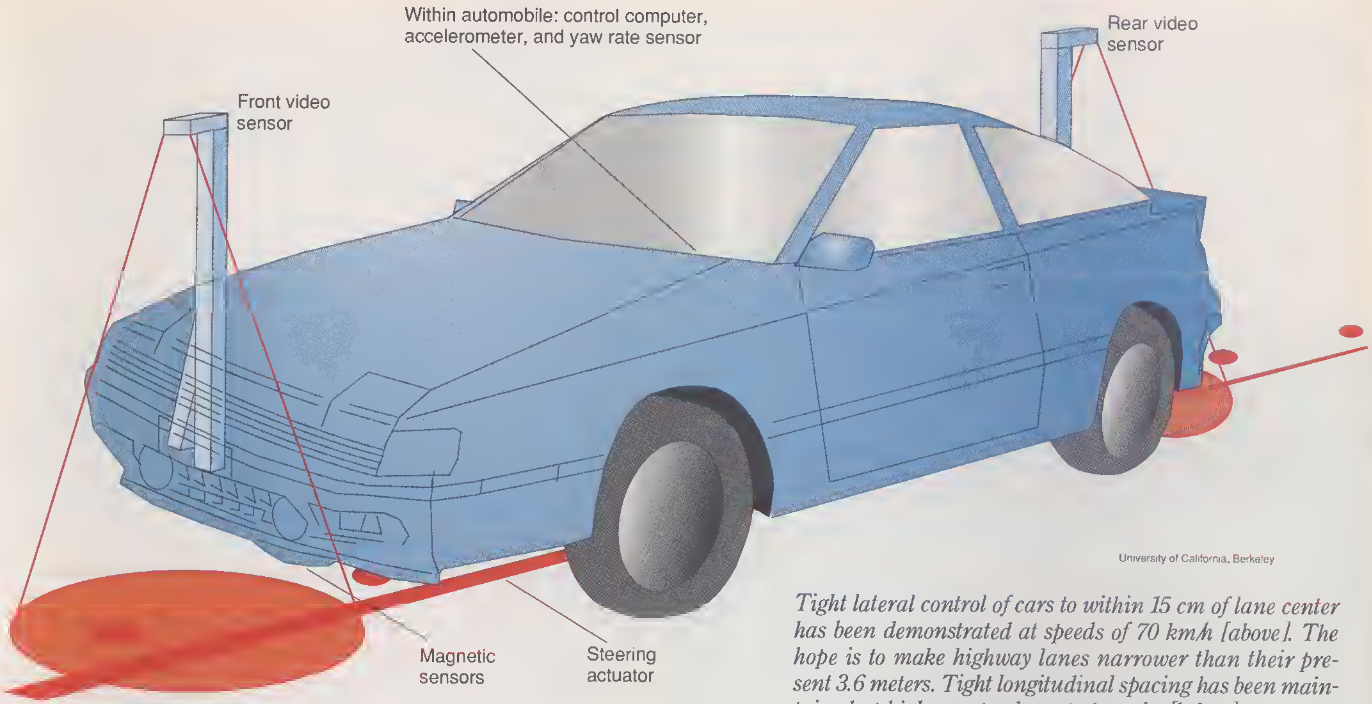
VEHICLE CONTROL. Nearing commercial deployment are a few driver aids for vehicle control. Automatic braking, for instance, makes it possible for a car to sense that it is nearing the vehicle ahead too quickly, while adaptive cruise control adjusts a car's speed to the pace of the vehicles around it.

Ultimately, IVHS may include systems that essentially do the driving for you—at least on stretches of highly instrumented roadways. There, computer-controlled cars would travel a meter or less apart at highway speeds. The tactic is called platooning. It requires electronically linked cars to travel in instrumented lanes with facilities to allow the vehicles to join and exit platoons smoothly at highway speeds. Estimates suggest that a single lane with automated facilities could carry as much traffic as three or four ordinary freeway lanes.

Although platooning may seem futuristic, several university programs have already successfully prototyped the concept, and Congress (in Istea) has mandated the establishment of a test track by 1997. In the California program called PATH (Partners for Advanced Transit and Highways), research-

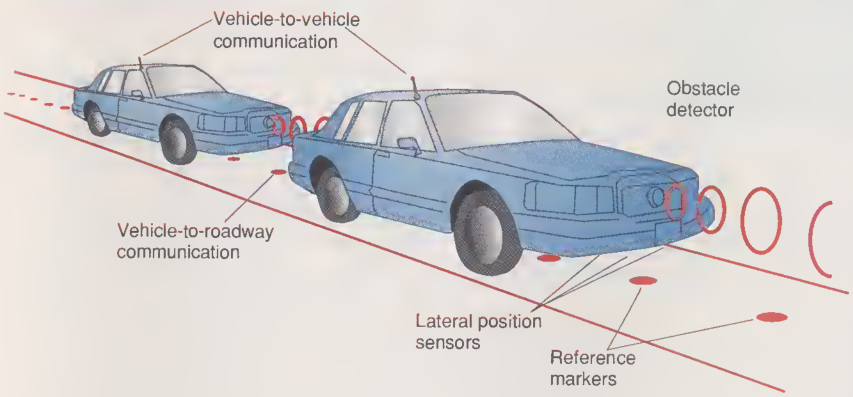
University of California, Berkeley

In a "smart highways" project, three cars equipped with systems for longitudinal control maintain a precise distance from each other as they follow a pacer car on a test strip north of San Diego, Calif.



University of California, Berkeley

Tight lateral control of cars to within 15 cm of lane center has been demonstrated at speeds of 70 km/h [above]. The hope is to make highway lanes narrower than their present 3.6 meters. Tight longitudinal spacing has been maintained at highway speeds on tesl tracks [below].



ers have already controlled platoons of up to four cars at speeds of 55 mph and higher, and they plan to platoon up to 20 cars in tests set for later this year [see picture above].

Steven Shladover, PATH's acting director, said tests show that it is possible to obtain very accurate lane holding (within 15 cm even under a variety of anomalous conditions) while maintaining excellent ride quality. Highway lanes could be much narrower once automated, said Shladover. The longitudinal-control tests have demonstrated the potential for high-precision vehicle-follower control when dynamic data obtained by ranging sensors are combined with communication between cars. In four-car platooning, the three followers were "slaved" to the manually driven leader, showing that spacing could be controlled accurately enough that riders could sense a rigid link between the vehicles while experiencing a reasonably good ride.

Shladover believes that if highway automation proves trustworthy, drivers will go for it. "We can't expect everyone to be enthusiastic from the start," he said. "But when people stuck in traffic see smart cars moving freely along automated lanes, they won't be hard to convince."

PUBLIC TRANSPORT. IVHS will also do well by public transportation by optimizing service (for instance, tripping traffic lights to permit buses to stay on time) and by delivering public transit information to homes, offices, and even bus and rail stops.

Mike Bolton, executive director for the Transportation Authority of Ann Arbor, Mich., is leading the development of an integrated public transit operation. Although such cities as Dallas and Denver are experimenting with pieces of multimodal technologies, Ann Arbor is the first to merge a comprehensive array of public and private transit systems. The city will place map-matching and vehicle-location systems in its buses, which will communicate with a traffic information center equipped to process and broadcast the transportation information on a reserved cable-TV channel. When cable becomes interactive, a transportation channel like Ann Arbor's might be expanded to include electronic Yellow Pages services, parking information, and other uses.

The streamlining of commercial operations is another important objective of IVHS in the United States. Automated systems for toll collection, permit acquisition, vehicle weighing, and vehicle identification can ease the burden of meeting the requirements of interstate red tape, delays that translate into millions of dollars in lost time and revenue. Commercial applications also promise to reduce emissions, because trucks produce their most harmful emissions while accelerating and decelerating.

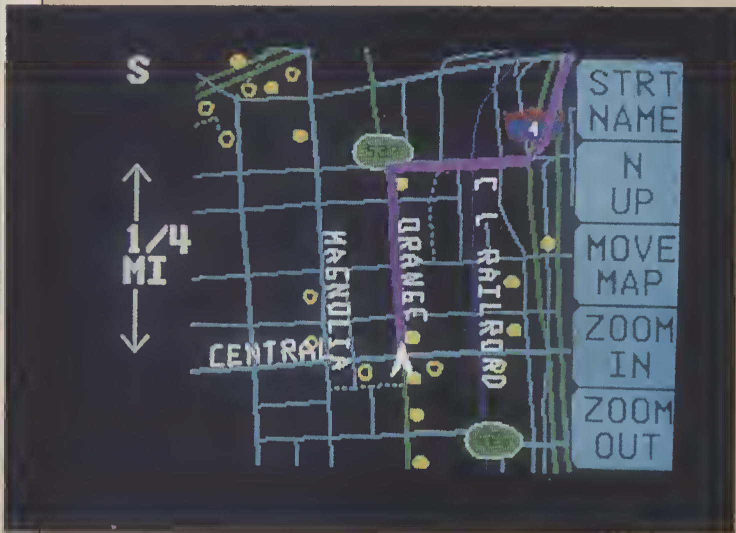
One program along these lines, Advantage I-75, employs automatic vehicle technologies to smooth traffic and bureaucracy on the busy Interstate 75 corridor, which runs from Ontario to Florida. Hughes Aircraft Co. is installing roadside beacons to read a truck's identification information while the vehicle is in motion. The beacons will forward the information to a checkpoint, which sends an ID confirmation to a responder installed on the vehicle's dashboard. If everything checks out, the driver need not stop. Member states are now busy selecting truck companies for the field test, scheduled to begin mid-year. "The challenge is to get the agencies and states to cooperate, so that the truckers can concentrate on moving goods, not paper," said Kunwar Rajendra, a Michigan Department of Transportation engineer who leads that state's Advantage I-75 effort.

The promoters of Advantage I-75 are trying to avoid the bureaucratic potholes that slowed the development of the pioneering Help Crescent project, which runs on an Interstate corridor from British Columbia down the West Coast to Texas. Help Cres-

Finding your way

In the early '90s, the Federal Highway Administration took a look at automotive business travel. It estimated that US $46 billion per year could be saved if routes were planned and followed better.

Until recently, the technology was not in place to remedy the situation. Now, computers and sensors have become small, powerful, and affordable enough, while accurate, timely, and content-rich digital street map databases have become available.



American Automobile Association

In the Orlando area in Florida, TravTek screens picked up satellite signals and emitted audible cues to guide motorists.

A route guidance system responds to queries like "Find the quickest way to 1456 Elm Street" by first noting the vehicle's present location and its rate and direction of travel. The system then calculates an efficient, legal route (figuring in any driver preferences, such as avoiding toll roads). After that, the system delivers timely directions to drivers, without distracting their attention from the road. Some systems will monitor real-time traffic situations and modify routes if conditions change.

There are two basic approaches to route guidance. In one, most of the technology resides in the vehicle (as in the TravTek and Advance projects, and those being sold in Oldsmobiles) and the infrastructure merely reports traffic conditions.

The other approach, being tested in Siemens' Ali-Scout projects in Europe and Michigan, uses a central system for calculating routes that take traffic conditions into account and communicate results to the vehicle through the infrastructure. In this case, the onboard equipment's prime role is to keep track of the vehicle's location.

Some experts, including Heinz Sodeikat, external relationships director for Siemens Automotive's Euro-Scout Project in Munich, and Russell Shields, chairman of Navigation Technologies Corp., Sunnyvale, Calif., believe a hybrid approach may evolve. The expense of infrastructure-controlled route guidance would be incurred only in densely populated city centers, while autonomous route-guidance systems would be used in less populous areas.

Autonomous route-guidance systems run on a computer in the vehicle. The machine is not only as powerful as a good home computer but also equipped with a map database. It interacts with three subsystems—sensors, user interface, and communications.

The sensor subsystem determines the vehicle's location and path of travel. Typical components include a compass (magnetic or gyro) and a displacement sensor (accelerometers or odometer feeds). Satellite tracking by the Global Positioning System (GPS) often supplements the other sensors. A GPS receiver in the car triangulates the vehicle's position on the basis of transmissions from a satellite network deployed by the U.S. Department of Defense. While it is very accurate for military targeting, for civilian applications the Defense Department introduces error as a security measure. Moreover, the necessary line of sight is often not reliable in areas with tall buildings or substantial tree cover. GPS is most effective when combined with dead-reckoning sensors and a map-matching algorithm.

The user-interface subsystem communicates with the driver, accepting requests for service and delivering driving directions and other information. Direction screens present simple, highly stylized graphics that can be taken in at a glance. Even so, developers of route guidance systems are focusing increasingly on digitized or synthesized voice as a means of delivering all turning instructions, so drivers keep their eyes on the road. A head-up display may prove useful here. Once the vehicle is parked, more elaborate screen displays enable the traveler to look up points of interest or listings in the Yellow Pages or to check directions.

Several approaches to mobile communications are being explored. The TravTek experiment in Orlando, Fla., used a two-way data radio for acquiring and delivering traffic information. The Ali-Scout route-guidance system uses infrared beacons. Cellular digital packet data (CDPD) and digital audio broadcast (DAB) have potential, as does the use of FM- and TV-subcarrier (for wide-area advisories) and microwave.

Besides interacting with hardware and performing other typical system-coordination roles, the software in route guidance systems includes several application-specific subsystems—for location determination, route calculation, and route guidance. Knowledge of the vehicle's location is key to most route guidance activities (and many other IVHS functions). For most purposes accuracy must be within 10 meters. Sensors give a good start, but GPS satellites may not always be within sight, compasses may be misled by magnetic interference, and accelerometers and odometers are subject to error that accumulates over time. To compensate for these sensor limitations, the software must evaluate the applicability of sensor feeds and correct the inaccuracies to which sensors are liable.

Most route guidance systems include a map-matching capability, which follows the apparent (sensed) progress of the vehicle along the on-board

cent, which at first had problems in avoiding institutional issues, has incorporated electronic license plates, automatic toll collection, and vehicle speed monitoring. It is also experimenting with technologies that weigh the cargo of a vehicle while it is moving; once perfected, they will be an important time and energy saver.

COUNTRY ROADS. While IVHS saves time in cities, it promises to save lives in rural communities, where more than half of all fatal accidents occur—often because victims are far from medical services.

A comprehensive infrastructure is still a long way off. But imminent safety technologies, some independently deployable, include automatic emergency signaling, in which a car's opening airbag trips an automatic distress alert, and lane-drift warning systems, which instruct a car wandering outside a marked lane to send an alarm to a dozing or distracted driver. Vorad Safety Systems (San Diego), Allstate Insurance, and Eaton Corp. are working together to develop new products for rural IVHS. The Dallas-based Greyhound bus fleet is already installing Vehicle On-board Radar systems, developed by Vorad, for collision warning.

JAPANESE APPROACHES. Japan and Europe have been exploring IVHS for more than 20 years. Although they share the same goal, their approaches are different. Japan's long-standing interest in IVHS has been sparked by a transportation network that can no longer keep pace with the nation's dense population, by increasing ownership of cars, and by nonlinear and often ambiguous labeling of streets and addresses.

Carmakers are now scrambling to make digital map systems more affordable and appealing to mainstream consumers, particularly in the light of Japan's slowing economy. In the meantime, sales of less expensive handheld units are approaching 50 000 a month and rising quickly. All these systems rely on a standardized digital map database completed by the Japan Digital Road Map Association.

Japan's Vehicle Information and Communications Systems (VICS) project, initiated in June 1993, combines information services and traffic management. Some 200 organizations—including the Ministry of Post and Telecommunications, the Ministry of Con-

map database. Even if the calibration of the compass is slightly off, the software can conclude that the vehicle is not drifting over the curb and across the lawn into someone's living room, but is in fact staying on the street.

Similarly, the software knows that turns occur at corners, even if the longitudinal sensors think the distance is a little short. Map matching can, in fact, help to identify systematic sensor errors and correct for them systematically as well. Surprisingly, map-matching software has little difficulty with busy, winding routes, given good digital maps: long, straight stretches pose the problems because of the lack of distinguishing features.

The route calculation subsystem determines a "best" route from the vehicle's current position to a chosen destination. Depending on the driver's preferences, "best" may mean least duration, least travel-time variability, least distance, fewest maneuvers, least tolls, or some weighted combination of these criteria. The calculated route must, of course, also conform to all driving rules (such as one-way streets and restrictions on turns and high-occupancy vehicle lanes). The route calculation algorithm treats the digital map database like a graph to be searched, with nodes and arcs appropriately weighted. More refined systems take real-time traffic information into account.

Once the optimal route is calculated, the route guidance subsystem has the task of delivering the directions to the driver. This is a critical area. Directions not only have to be clear and nondistracting, but must be timely as well. Too late, and maneuvers may be sudden or missed; too soon, and maneuvers may be performed prematurely or instructions may be forgotten. Timing depends, among other things, on both the vehicle speed and the complexity of the maneuver.

Most current test and prototype guidance systems deliver directions both as simple graphics and as computer voice. One helpful outcome of the TravTek project in Florida was recognizing the value of having the voice directions include the destination roadway's name, and not just say, "Right turn ahead." *—W.C.C. and R.J.W.*

struction, the National Police Agency, and a wide range of electronics suppliers and car manufacturers—are sponsoring the project. "Before, the government had no interface between police, construction, and communications, so jurisdictional competition was normal," said Michima Ogawa, manager of systems development engineering for Nippondenso, one of the world's largest automotive electronics firm, and a navigation system supplier to Toyota. "Now, for the first time, they must partner with each other and private companies."

EUROPE'S DRIVE. In Europe, Road Transport Informatics emphasizes a multimodal element of travel. The largest cooperative program to date is the $800 million Prometheus (Program for European Traffic with Highway Efficiency and Unprecedented Safety), part of the 19-country Eureka European Research Agency. Another prominent European effort is Drive (Dedicated Road Infrastructure for Vehicle Safety in Europe).

Drive is pushing the development of a common European road system in which smart cars communicate and cooperate with a smart infrastructure that monitors and issues reports on up-to-the-minute traffic conditions. So far, $140 million, more than half of which was staked by private industry, has been spent in the project's first phase to develop appropriate technologies. Now, well into the second phase, an additional $280 million is being spent to prove that those technologies can work, in such multi-city projects as Quartet (Birmingham, Stuttgart, Athens, Turin), Melyssa (the Mediterranean-Lyon corridor), and Gerdien, a Dutch-inspired interurban traffic management project.

Europe has taken a lead in general information provision systems to aid travelers. The French have access to the seemingly ubiquitous Minitel, which offers an online service to check train schedules and make reservations from most homes and offices. The Dutch rail service furnishes easy-to-use PC software that displays complete schedule and routing information for trains throughout Europe.

Automatic toll collection continues to be deployed at a fast rate, and contactless smart-card technology is being used as well. In England, the Greater Manchester Passenger Executive, a project that started in February, is distributing some 500 000 smart cards to travelers entitled to concessionary fares on the area's nearly 3000 buses. The cards will facilitate cashless payment for passengers as they get on board and validate their right to lower fares. Organizers are also exploring other uses for the card, such as paying for groceries.

Europe's leaders have planned the successor to Drive II: Fourth Framework, a four-year project beginning this year. Initial guidelines suggest that the undertaking will emphasize full integration of air, rail, road, and marine transport.

GRAND CHALLENGES. If IVHS is truly to revitalize troubled transportation systems, various applications (and successive generations of them, at that) must work together cohesively and flexibly. One of the most urgent concerns is establishing a system architecture to control this interaction.

At the urging of IVHS America, the Federal Highway Administration awarded contracts last September to four competing teams to explore and propose architecture scenarios. Each team—comprising transportation, communications, and computer experts—will defend a practical, deployable architecture that uses the existing infrastructure to the greatest possible extent. "It will be a three-year effort that will lead to standards and guide IVHS deployment," said FHA's Euler.

Integrating IVHS subsystems in an open environment will require an industry agreement on interface standards and protocols. The system architecture effort will derive some of them, but others must be put in place as rapidly as possible—without, however, prematurely impeding technical development. The IEEE has formed a standards coordinating committee (SCC-32) to address IVHS concerns, with participation from the Vehicular Technology Society, the Computer Society, the Communications Society, and other bodies. In addition, the Institute's Technical Activities Board is forming an ad hoc committee on IVHS to assess further involvement in such areas as education and technical conferences. The Society of Automotive Engineers and the American Society of Testing and Materials are also pursuing IVHS standards.

Nontechnical impediments, such as money for deployment, may be the toughest hurdles for IVHS. Without regulatory or industry guidelines, issues like antitrust, patent rights, liability, and privacy may deter investors. Particularly in the United States, where the overwhelming majority of roadways—even interstate highways—are owned by state and local governments, IVHS faces a jurisdictional quagmire. Yet with organizations such as IVHS America and field tests such as Advantage I-75 showing the benefits of cooperation, other large-scale initiatives are sure to follow.

Whatever the difficulties of deploying IVHS technologies, the rewards should be well worth it. Though the transportation industry is conservative, traveler demand and national interests dictate that it provide greater safety and efficiency through the application of existing information age technologies.

TO PROBE FURTHER. The Fourth Annual Meeting of the Intelligent Vehicle Highway Society of America is scheduled for April 17–20 in Atlanta, Ga. The nonprofit organization and Federal advisory group also publishes newsletters and reports. Contact: IVHS America, 400 Virginia Ave., S.W., Suite 800, Washington, D.C. 20024; 202-484-4847.

This year's IEEE Vehicular Conference will be held June 7–10 in Stockholm, Sweden. For more information, contact Thomas Sidenbladh of Ericsson Radio Systems, Stockholm, by phone at (46 + 8) 757 3844 or by fax at (46 + 8) 751 2309. ◆

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Complying with Union rules

Trade with today's European Union must tangle with a complex new set of more stringent product requirements

The establishment of a single European market is sending shock waves throughout the nations that trade with the European Union (formerly the European Community). Implementation of new directives that will control the way suppliers certify and sell products within the European Union (EU) is under way. The final dates for compliance with many of these directives are already set, and suppliers who fail to comply face the prospect of having their products barred from the huge European marketplace.

The original European Community, established in 1957 by the Treaty of Rome, has reorganized itself into a single trading unit. Customs barriers, restrictions on the movement of people, and national regulations on the design and manufacture of products and services are soon to be things of the past. New rules and regulations aiming at the removal of barriers within the EU have gradually been incorporated into the national laws of member countries. This process was formally recognized by the launching of the European Single Market on Jan. 1, 1993.

Annual exports from the United States to EU countries have risen well above the US $100 billion mark [right]; for example, annual exports of telecommunications equipment reached $3.3 billion in 1992 [Table 1]. As the EU slowly pulls out of recession, the level of exports could climb even higher. Since much of this trade involves products that will have to comply with the new directives, it is essential that U. S. suppliers, and those in other countries, who hope to increase sales to the EU understand the implications of those directives and the urgency of meeting their requirements.

Under the new regime, companies whose products are certified in one EU country will be able to sell those products in other member countries as well. This important marketing advantage has not been lost on U.S. suppliers. Moreover, the way should also be eased for the many small companies in the United States that have been reluctant to trade in Europe because of language barriers that have hindered communication with regulatory bodies. The Single Market, it is hoped, will simplify the current hodgepodge of laws and requirements that vary from country to country. As Timothy J. Hauser, under secretary for international trade at the U.S. Department of Commerce, put it: "...U.S. business interests, particularly exporters, stand to gain as...EU consumers more fully adapt to an internal market without borders. In fact, most U.S. businesses support implementation of the Single Market program at a faster pace."

As is highlighted later in this article, U.S. industry is not alone in its lack of awareness of the new directives. This is no excuse, nonetheless. Company officers should recognize that if they persist in selling products that are not correctly declared as being in conformity with the appropriate directive, they are committing an offense and breaking European Union law.

This state of affairs does not impact them directly. There are, for example, no extradition treaties between the EU countries and the United States for such an offense. However, their company's EU manufacturing arm or representative could be taken to court and its products taken off the market. It is therefore essential that all manufacturers exporting to the EU undertake to achieve the certification of their products sooner rather than later. Sale of a noncompliant product either one minute or one year after the introduction of the directive is one and the same offense. The decision can no longer be delayed.

NEW APPROACH. In 1985 the Union adopted a new approach to technical standards, defined in directives that set forth essential requirements in the areas of health, safety, consumer protection, and environmental impact [see "A briefing on European Union directives"]. These directives, the technical details of which are being worked out in the form of EU-wide standards, apply to nearly all electrotechnical products and many others placed on the market. Products that comply with the directives will carry the CE (Communité Européenne) mark, indicating that they comply with all applicable "new approach" directives and that they should not be refused entry on technical grounds into any member country.

The new approach to standards is intended to remove existing trade barriers created by mandates that products be retested and recertified for use in individual countries. Compliance with such national requirements, whether imposed by law or by individual users or buyers, can be expensive and time-consuming.

Martin Green
Interference Technology International

U.S. export trade with the European Community*

(billions of U.S. dollars)

Source: US-EC Trade Statistics, Bureau of the Census, U.S. Department of Commerce

*The European Community changed its name to European Union in November 1993.

Exports from the United States to European Union countries rose from US $55 billion in 1980 to $115 billion in 1992. Suppliers' ability to comply with Union directives may determine whether this trend continues.

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In the future, products will have to be checked only once to be legally acceptable, or declared compliant, in all EU countries. To reduce the amount of retesting that may be required by buyers and users, the Union is setting up common criteria for assessing test laboratories and certification bodies. This effort is coordinated by the European Organization for Testing and Certification (EOTC) in Brussels, Belgium. Again, the goal is to make testing of a product in one member country sufficient for it to be used throughout the Union.

Suppliers may comply with EU directives by stating that their product was made in accordance with the relevant European standards or by demonstrating that the producer's own or some alternative standards satisfy the requirements of those directives. Once compliance has been demonstrated, the supplier affixes the CE mark and the EU declaration(s) of conformity and the product is ready to be shipped to any country within the EU. Without this mark, its sale in the Union is illegal. Enforcement is up to the member countries. In the United Kingdom, for example, selling a product that does not comply with the EMC directive is a criminal offense punishable by fines of up to £5000 (about US $7300) and three months' imprisonment. In Germany, such a sale is a civil offense punishable by a fine of up to DM 100 000 (about $57 000).

Table 2 lists new directives currently in force or in the planning stage. It is by no means a final list, since additional product types requiring regulation continue to be identified. The ones listed here are mainly designed to ensure the safety of personnel using the product or the safety of important resources such as the telecommunication network. In the case of medical devices it is intended to ensure the safety of operators and, of course, the patients.

1. U.S. technical products exported to West Europe, 1992

Product type	Billions of U.S. dollars
Equipment and parts	13.1
Instruments, medical and other	6.2
Electrical memory	3.9
Telecommunications equipment	3.3

Source: U.S. Department of Commerce

EMC DIRECTIVE. The electromagnetic compatibility [EMC] directive is perhaps the most complex and far-reaching, since it covers virtually all electric and electronic appliances and systems that might be placed on the market in the EU. It is intended to ensure that no product within its scope emits sufficient radiation to cause problems with telecommunications or other communication equipment, and that all such products are protected by adequate built-in electromagnetic immunity. Generally, suppliers can meet these criteria by complying with Union-wide standards from Cenelec (the European Committee for Electrotechnical Standardization, Brussels), the European standards-making body.

The EMC directive originally required that all relevant products placed on the market after Dec. 31, 1991, comply with its provisions. Later, a transition period of four years was established for the EMC directive by the Council of Ministers of the European Union. This extended the compliance deadline to products placed on the market after Dec. 31, 1995. The rationale for the extension was that suppliers had neither the means nor the time to meet the original deadline. All the necessary standards and procedures to implement the EMC directive are now in place, however, and there will be no further extensions.

EMC COMPLIANCE. To comply with the EMC directive, a supplier can apply Cenelec standards and then claim to be in compliance. Testing to verify conformity with the standards may be done in whatever manner the supplier wishes, and no test results must be presented.

Suppliers that decide not to apply, or are unable to apply, all the relevant Cenelec standards can create their own standards. The EMC directive requires that they present information on their product to an EU-competent body ["Where EU-competent and EU-notified bodies stand," next page] in the form of a technical construction file that includes items like product specifications and drawings, EMC design aspects, production processes, and test plans and results. If the competent body issues a favorable technical report or a certificate, the supplier can then claim compliance with the EMC directive.

Suppliers of certain types of radiocommunication transmitters must present their product to an EU-notified (rather than an EU-competent) body, which examines its design and performance. If the product is found compliant, the notified body issues an EU Type Examination certificate, allowing the supplier to claim compliance with the EMC directive.

Some EU-competent bodies will accept the results of U.S. laboratory tests, including those of the supplier's own laboratory; others may insist on Union-based testing. The decision should depend on the body's confidence in the results presented to it.

Whether compliance is achieved through conformity with Cenelec standards or through EU-notified or EU-competent bodies, the supplier claims it by making an EU

A briefing on European Union directives

Over 280 European Union (EU) directives have been approved to date and many more are in the process of approval. When the European Commission identifies some aspect of the economic life of the European Union that requires regulation, the relevant department prepares a directive. The text of the directive is then passed on to the Council of Ministers of the 12 member countries for discussion, amendment, adoption, or rejection. When approved, a directive includes a deadline for incorporation by member countries into their national laws. Directives are binding on the member countries, but the method of implementing them is left to the national governments.

Implementing directives may not always be a smooth and easy process. Enforcement is up to the member states, but national attitudes toward the measures can vary. A member country may view a directive as contrary to its national interests and choose not to apply it. The EU then has the power to fine the recalcitrant member country, and such fines can be heavy—tens of millions of dollars or more. The European Court of Justice has an oversight role in ensuring a common approach to the application of EU laws, including the implementation of directives.

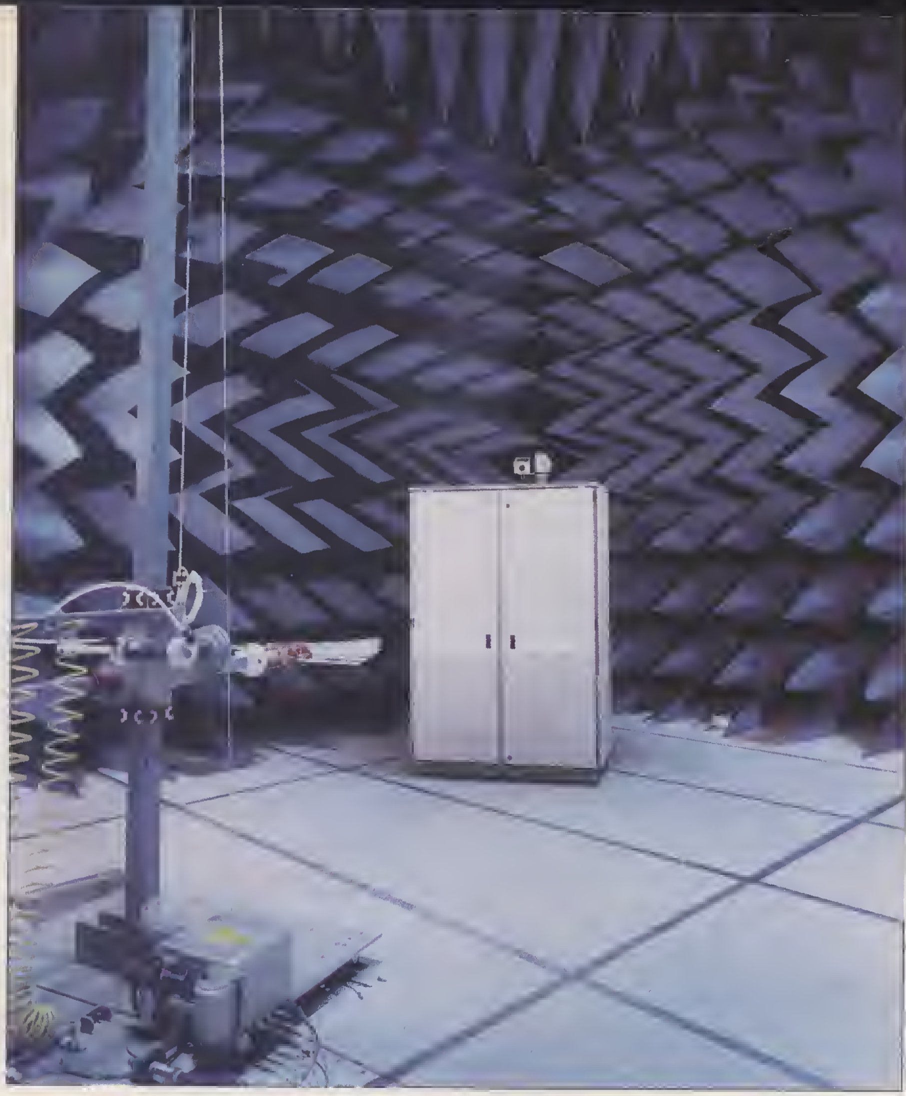
Sometimes there is confusion in the application of directives. For example, Bob Straetz, international trade specialist at the U.S. Department of Commerce, reported in *Business America* (the department's bi-weekly publication) that U.S. exporters who met the requirements of the EU toy safety directive were rebuffed when they tried to get their products into Italy. Italian custom officials had no knowledge of the EU directive.

Some directives are operational, designed to regulate such matters as customs arrangements and company law for EU countries. For example, a directive designed to control the introduction of national regulations that might create barriers to trade requires member countries to notify the European Commission of all new technical regulations relating to any industrial or agricultural product. This gives each country a chance to object to any new regulation it judges to be a barrier to trade. Such a regulation can be automatically frozen from three months to up to a year, giving the Commission time to propose an EU-wide remedy.

Other EC directives are technical, designed to regulate the manufacture and sale of goods. Some are meant to protect the consumer, such as the doorstep-selling directive, which calls for a seven-day cooling off period for certain sales, and the dangerous-initiatives directive, which concerns imitation food products that may be misrepresented to consumers. The low-voltage directive covers electrical equipment safety for products that operate at 75 to 1500 V dc and 50 to 1000 V ac.

Actually, formulation of directives is only one of the ways in which EU bodies can communicate with member countries. The European Commission can make regulations applicable to member countries without reference to their national parliaments. The EU Council of Ministers can make decisions addressed to member countries, to companies, or to individuals. EU bodies may also issue nonbinding recommendations and opinions.

—*M.G.*



GEC Plessey Telecommunications Ltd

For products to be sold in Europe, radiated emissions will have to meet the requirements of an electromagnetic compatibility directive that goes into effect Dec. 31, 1995. Here, such emissions are being measured for a telecommunications cabinet.

declaration of conformity. Suppliers from EU countries can do this directly; others outside the EU can have their declaration made through a representative within the Union.

After making the declaration of conformity, the supplier applies the CE mark to the product, indicating that it complies with the EMC directive and with all other applicable new directives (such as the low-voltage directive).

STANDARDS CHOICE. Before the arrival of the Dec. 31, 1995, compliance deadline for the EMC directive, suppliers in the EU may conform either to it or to their own national standards. Germany currently has national standards governing emissions from information and telecommuncations equipment (ITE), domestic appliances, industrial control equipment, and lamps and luminaries. British emissions regulations cover similar products, but exclude ITE.

Comparison of the EMC directive with comparable requirements outside Europe suggests that compliance procedures in the EU may be excessively complex. For example, the rules for ITE of the Federal Communications Commission (FCC) in the United States are designed to control emissions in much the same way as Europe's Cenelec standards. But unlike Cenelec, the FCC does not attempt to control product immunity from electromagnetic radiation.

In Japan, EMC controls for ITE are essentially voluntary and are based on standards similar to Cenelec standards for emissions control. Like the United States, Japan has thus far taken no steps to implement standards covering product immunity from electromagnetic radiation. However, inquiries received from Japan at the UK Department of Trade and Industry indicate that all aspects of the EMC directive are being taken very seriously there, and major Japanese suppliers are moving to ensure that all their products comply. Australia, too, is treating the requirements of the EMC directive very seriously and is adopting Cenelec standards as its own.

In general, there are no national provisions within the EU countries to control product immunity from electromagnetic radiation. The exception is Denmark, where all the standards published in the Official Journal of the EU have been adopted as national standards.

In other countries, immunity standards are currently being used in the certification of products whose failure could result in a threat to human life. The most obvious example is flight certification of aircraft. International and national regulatory agencies, such as the U.S. Federal Aviation Administration, have electromagnetic immunity clearance procedures for aircraft prior to takeoff.

COMPLIANCE READINESS. The extent of suppliers' awareness of the new EU directives is unclear. In November 1992 a survey conducted by Benchmark Research, Swanley, Kent, found that 69 percent of British companies were aware of the EMC directive, and 15 percent believed they did not have to comply. However, only 16 percent stated that their products were fully compliant.

Where EU-competent and EU-notified bodies stand

European Union (EU)-competent bodies have the authority to judge whether standards created by a supplier are in conformity with the Union's electromagnetic compatibility (EMC) directive. Since their assessments may be based on performance to a test standard or on an assessor's subjective judgment, these bodies must have in-depth experience in EMC.

EU-notified bodies act as independent assessors of many products, including medical devices, telecommunications terminal equipment, and radio communication transmission equipment. These bodies have the authority to judge whether such products are in conformity with all relevant Union directives. Generally, certification by an EU-notified body is needed whenever use of a product poses a significant safety hazard or whenever there is the possibility of damage to a public utility system.

EU-competent and EU-notified bodies recognized by the European Commission are appointed by the national governments of all the member countries, and they are legally answerable to those governments.

The EU legal system has, as yet, made no provision for appointment of EU-competent or EU-notified bodies in non-Union countries. At present, the European Commission does not have the power to make such appointments, and will be able to do so only when the European Parliament passes a law giving it that power.

It is unlikely that any U.S.-based bodies will be appointed until the Union concludes Mutual Recognition Agreements with the United States. It may demand relaxation in other trade matters before it agrees to accept bodies appointed by the U.S. government.

The only EU-competent and EU-notified bodies currently located in the United States are Union-based organizations that have been appointed as competent and have U.S. sales or technical support offices.

—M.G.

Early in 1993, the UK Department of Trade and Industry launched an awareness campaign to stress the problems of uncontrolled EMC and the need for the directive. The campaign included the publication of numerous articles in technical and management journals. Meanwhile, the popular media concentrated on the drama of EMC-related problems, failing to emphasize the responsibility of suppliers to ensure that their products comply with the directive.

Results of a follow-up survey indicated that over 90 percent of senior personnel in the UK now believe that EMC is very important to their business. However, the extent to which British industry is aware of the consequences of selling noncompliant products or of failing to comply by the Dec. 31, 1995, deadline is unknown.

Queries received from Japan indicate a high level of interest in EMC standards and in complying with the EMC directive. There has been little publicity in EU countries or in the United States, however, and there is no way of knowing the extent to which industry as a whole is prepared for the compliance deadline.

QUALITY CONTROL. Considerable emphasis has been put on the need for adequate quality control as a prerequisite to selling products in the EU. Actually, no EU directive mandates suppliers' quality control systems that meet given requirements. But individual countries within the Union do demand that products be manufactured to acceptable quality standards. This is particularly true of medical products.

In the United Kingdom, approval authorities often insist that a supplier have in place a quality control system that conforms to ISO 9001/EN 29001/BS 5750 Pt 1 standards before it can sell production quantities of its products. If such a system is not in place, the supplier's products may require significantly increased assessment. This may involve detailed studies of the manufacturer's internal quality systems and may be essentially equivalent to an ISO 9000 audit. The products may also be subject to a more detailed check as to quality and performance. In the United States, ANSI/ASQ Q92, which is a version of the ISO 9002 standard, seems to be replacing existing Food and Drug Administration requirements for good manufacturing practice.

The European Commission issued its Com(89)209 document on a global approach to certification and testing in July 1989. This document does not cover EMC testing but is applicable to other types of products. The goal of the global approach is mutual recognition among EU countries of testing and certification practices so that products can be sold in more than one country without the need for multiple tests.

The EN 45000 and EN 29000 specifications were issued as guidelines by the EU. Their purpose was to establish the international credibility of the bodies responsible for certification and inspection of testing laboratories and quality control systems. There is no legal requirement to adopt these specifications, and there are no national laws that require compliance with them. However, there are provisions in several EU directives that grant a presumption of compliance to the product of a supplier that demonstrates compliance with EN 29000.

Such a supplier may, as part of the EU Type Approval process, be subject to surveillance of its manufacturing process and quality control system by an EU-notified body. It is the responsibility of the supplier to ensure and declare that the product satisfies the requirements of relevant directives. In some cases, the EU-notified body may wish to verify the conformity of the product design to directive requirements. The presumption of compliance offers a way to avoid the considerable effort that might otherwise be spent examining production products.

2. 'New approach' directives from the European Union

Directive	Date in force	Transition date
Cable ways	(a)	
Construction products	June 27, 1991	Indefinite
Electromagnetic compatibility	Jan. 1, 1992	Dec. 31, 1995
Elevators	(a)	
Furniture flammability	(a)	
Gas appliances	Jan. 1, 1992	Dec. 31, 1995
In-vitro diagnostic devices	(a)	
Low voltage	Jan. 1, 1992	Dec. 31, 1996
Machinery	Dec. 31, 1992	Dec. 31, 1994
Measuring instruments	(a)	
Medical devices, active implantable	Jan. 1, 1993	Dec. 31, 1996
Personal protective equipment	July 1, 1992	Dec. 31, 1994
Playground equipment	(a)	
Pressure equipment	(a)	
Pressure vessels, simple	July 1, 1990	July 1, 1992
Recreational craft	(a)	
Satellite earth station equipment	(a)	
Telecommunications terminal equipment	Nov. 6, 1992	None
Toy safety	Jan. 1, 1990	None
Weighing instruments, nonautomatic	Jan. 1, 1993	Jan. 1, 2003

(a) Being planned.

TO PROBE FURTHER. Literature and business briefings covering the requirements for product sales in the European Union (EU) are available from the Office of European Community Affairs, U.S. Department of Commerce, Room 3036, Washington, DC 20230; 202-482-5276; fax, 202-482-2155. Information on foreign product standards is also available from the Commerce Department's National Institute of Standards and Technology, which operates the National Center for Standards and Certification Information. It can be reached at 301-975-4040.

Also of interest are the special editions of *Business America*, published by the Commerce Department, that deal with commercial developments in the EU. Write to *Business America*, U.S. Department of Commerce, Room 3414, Washington, DC 20230; 202-482-3251; fax, 202-482-5819.

The UK Department of Trade and Industry has published a wide range of advisory documents covering most of the new approach directives, as well as briefing documents on the requirements of the European Single Market. Of particular relevance are the "Products Standards" documents covering electromagnetic compatibility and machinery. The UK Department of Health produces a similar range of documents covering compliance with the directive on medical devices and the directive on active implantable medical devices. These are not generally available for distribution to the United States, but copies may be obtained from Technology International Inc., 705 Twin Ridge Lane, Richmond, VA 23235; 804-560-5334; fax, 804-560-5342.

In the UK, contact Department of Trade and Industry, Ashdown House, 123 Victoria St., London SW 1E 6RB; 071-215-5000; and Department of Health, Richmond House, 79 Whitehall, London SW 1A 2NS; 071-210-5963.

General reading and advice on the EMC directive may be obtained from *The Guide to the EMC Directive* by Chris Marshman (IEEE Press, New York, 1993). ◆

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Degrees and diversity at work

A study of engineers and scientists in the United States explored the interplay of gender, immigrant status, and education

Scientists and engineers, especially those in research organizations, agree that education matters. They do not, however, agree about what difference it actually makes. One thing is clear: the career experiences of scientists and engineers who hold doctorates often differ quite sharply from those of counterparts with master's or bachelor's degrees, many of whom are engineers. Ph.D.s tend to focus more on professional development than on careers in management, although they are often critical of it. They tend to be more involved with their work than others are, to expect more autonomy in defining their research goals, and to take the lead in developing and directing work projects. They also are assumed, by themselves and others, to be the primary reservoir of technical knowledge.

Nancy DiTomaso, George F. Farris
Rutgers University,
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In a recent study of 3163 scientists and engineers in 24 companies based in the United States [see "About the survey," below], we found that having a Ph.D. matters in these predictable ways. Yet the effects for women as opposed to men were the reverse of those for U.S.-born as opposed to foreign-born respondents. The survey responses of women converged with those of men as educational levels increased. But as the educational levels of foreign-born scientists and engineers increase, their experiences seem to diverge more and more from those of similarly educated professionals born in the United States.

All of the respondents worked on the technical staffs of major research and development facilities. For the purposes of our analysis we excluded those respondents without at least a bachelor's degree, about 6 percent of our total sample. Of course, the differences we observed may have resulted from the type of degree our respondents earned—that is, a degree in science or in engineering—as well as from the level of that degree. Because many Ph.D.s have degrees in science and many of those with bachelor's and master's degrees are engineers, we could not separate the type of degree from its level in this study. Even so, we suspect that both factors affect the ways scientists and engineers experience their jobs.

The most pertinent work experiences concern job performance and professional self-esteem. Drawing both on past work about the management of scientists and engineers and on the results of our own study, we examined what our respondents said about how they spent their time, their commitment to work, their interactions with others, and their technical performance. For each comparison, we analyzed differences within each educational level [see "Analyzing the data," last page]. Figures 1 through 9 provide graphical displays of the mean differences within each educational level both by gender (men and women) and birthplace (U.S.-born and foreign-born).

DIVERSITY. Past research on scientists and engineers has found that working on more than one project tends to improve job performance by exposing these professionals to a wider variety of ideas and experiences than a single project could. In this fundamental sense, diversity of experience enhances performance. In our study, although women with bachelor's and master's degrees were more likely than their male counterparts to work

About the survey

This article is based on a survey of 3163 employed scientists and engineers in the research and development units of 24 major U.S. companies. The study, which aimed to improve our understanding of the management of a diverse scientific workforce, was funded by the Center for Innovation Management Studies at Lehigh University, Bethlehem, Pa., and received a recent grant from the Sloan Foundation to continue the analysis on immigrants as compared with the U.S.-born.

During the data collection stage, support was also provided by the Industrial Research Institute, Washington, D.C., and by the Technology Management Research Center, Rutgers University, Newark, N.J. We promised confidentiality to all of the companies and respondents.

The 24 businesses participating in the study included electronics and communications companies (accounting for about 700–800 of the respondents), as well as companies that produce chemicals, industrial gases, petroleum, basic metals, pharmaceuticals, and consumer products. All are engaged in industrial R&D and all are multibillion-dollar enterprises. Although most of them are based on the East Coast, many have facilities elsewhere, and companies from the Midwest, the South, and the West were also included.

Respondents by race/ethnicity and birthplace

		Male	Female
U.S. born	White	1763	474
	Other	124 (20)	94 (16)
Other	White	179	37
	Other	307 (225)	82 (59)

Numbers in parenthesis indicate Asians in group.

The authors developed the questionnaire for the survey from focus groups and interviews in five large R&D facilities. The questionnaire addressed work characteristics, careers, relations with others (including supervisors and the work group), work and family life, and performance. The study also included data from managers on the job performance of the respondents; this information was compared with their perceptions of themselves. No information was collected on the types of degrees they held.

Some surveys were administered in group meetings at company sites; others were sent by mail. The overall return rate was 55 percent, and the number of respondents per company ranged from 25 to 650.

The respondents numbered 3163 and included:
- 187 with less than a bachelor's degree.
- 1125 with a bachelor's degrees.
- 933 with a master's degree.
- 918 with a Ph.D.

(The numbers do not add up to 3163 because of missing data.)

Details of the group's composition in terms of race or ethnicity and birthplace are displayed in the accompanying table.

The respondents to the survey were about equally divided among four seniority categories: less than two years; three–nine years; 10–20 years; and 21-plus years. The U.S.-born white males were, on average, older than the members of any of the other groups.

—N.D., G.F.F., and R.C.

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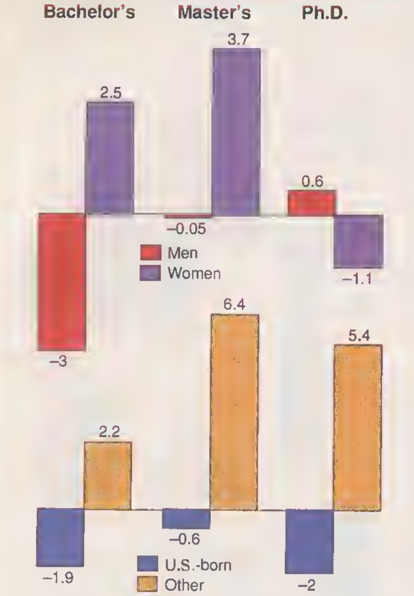
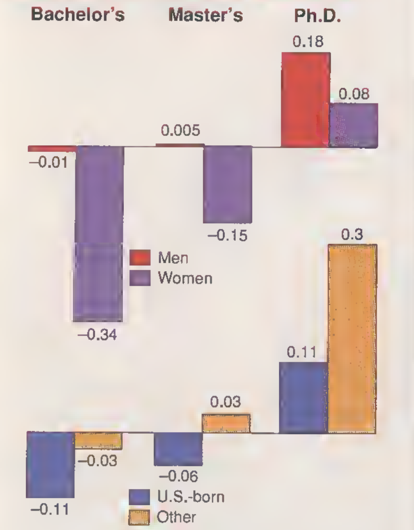
Time spent on one major project, percent



Source: Rutgers University Study of Diversity in R&D (all bar charts)

[1] Women scientists and engineers with bachelor's or master's degrees reported spending a higher proportion of their time on a single major project than their male colleagues did. Those with Ph.D.s, however, spent slightly less of their time on such projects than did their male colleagues [top]. Scientists and engineers born in countries other than the United States spent a higher proportion of their time on one major project as compared with their U.S.-born colleagues [bottom]. In both bar charts, the numbers are deviations from the grand mean of 54.4 percent for the entire group of respondents.

Opportunity for inventing or initiating



[2] Women scientists and engineers reported less opportunity for inventing or initiating projects than did their male counterparts [top]. U.S.-born reported less opportunity to invent and initiate projects than their immigrant counterparts [bottom]. Results are in units of standard deviation.

on a single major project, women with Ph.D.s did not differ much from men in this respect [Fig. 1, top]. By contrast, immigrants at all educational levels spent a higher proportion of their time on one major project than native-born scientists and engineers did; the gap was greatest for those with master's and doctoral degrees [Fig. 1, bottom].

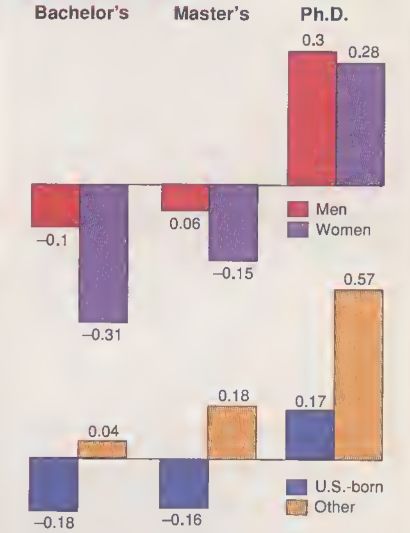
Opportunities to invent or initiate new projects exhibited the same pattern [Fig. 2]. At every educational level, women were less likely than men to have such opportunities, but the differences between the sexes were narrower for those with master's and Ph.D. degrees. In contrast, the gap between U.S.-born and other scientists and engineers was greatest for those with a doctorate. Presumably, in an environment that depends on innovation, opportunities to invent or initiate new projects are advantageous, and a willingness to innovate will be rewarded and positively assessed in performance evaluations. In this respect, Ph.D.s enjoyed more favorable prospects, but holding a doctorate does not affect gender and birthplace differences in the same way.

INVOLVEMENT. Commitment to work is another issue that is often assumed to affect performance. Rightly or not, companies often measure the seriousness of that commitment by the amount of time or attention employees devote explicitly to their jobs. Past studies on commitment have often measured it by asking respondents how "involved" they were in their work—that is, whether they thought about it "night and day." In our survey, women with bachelor's degrees were less involved with work than their male counterparts, but the gap narrowed for those with master's and doctoral degrees [Fig. 3, top]. At all educational levels, scientists and engineers born outside the United States were more likely than the U.S.-born to say that they were highly involved in their work, but the gap widened as educational levels rose [Fig. 3, bottom].

Managers seem to believe that involvement with personal life comes at the expense of involvement with work [Fig. 4]; there is a positive correlation between employees' involvement with work and managers' evaluations of their performance, as well as a negative correlation between the importance of personal life and performance evaluation. Ph.D.s were much less concerned to find time for their personal lives than the others were—but, again, the patterns varied by gender and birthplace. Women with bachelor's and master's degrees were more likely than men to say that it was important to have time for their personal lives, but for Ph.D.s the difference between the sexes was negligible. At each educational level, the U.S.-born gave a higher priority to their personal lives than the rest did, but the difference was statistically significant only for those with doctoral degrees: non-U.S.-born Ph.D.s were a good deal less likely to share this concern than their indigenous counterparts.

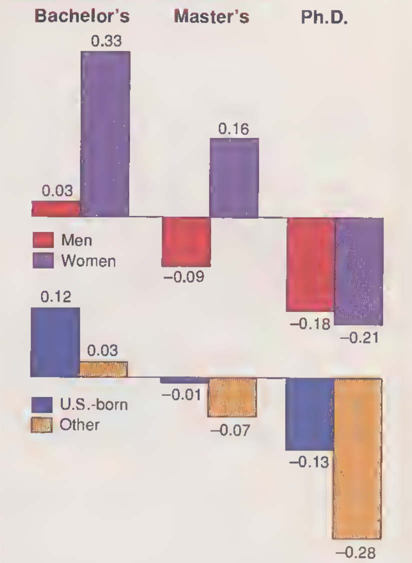
"Technical control" is the ability to influence the choice of work goals. By implication, those who have it are sufficiently trusted or experienced to choose their own work assignments. In this respect, women Ph.D.s resembled their male counterparts more than women with bachelor's or master's degrees did [Fig. 5, top]. At each educational level, the U.S.-born enjoyed more technical

Involvement in work



[3] Men reported having a higher degree of involvement in their work than the women did [top]. Those not born in the United States reported being more involved than their U.S.-born counterparts in the [bottom]. The numbers, measured on a scale of 1 (low) to 7 (high), are deviations from the grand mean of 4.76.

Importance of personal life



[4] Personal life is more important to female than to male respondents at the bachelor's and master's levels [top], as well as to U.S.-born respondents, as compared with their non-U.S. counterparts [bottom]. The bar charts, measured in standard deviation units, reflect the analysis of such factors as having enough time for family.

control than immigrants did, and the gap was especially great for those with master's and Ph.D. degrees [Fig. 5, bottom].

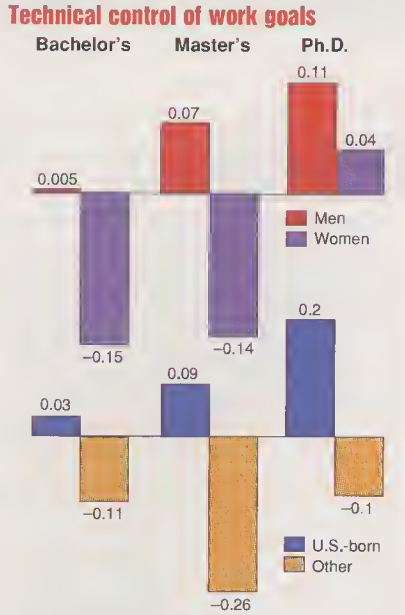
Those who have influence in their work groups are more trusted by their colleagues than other employees are [Fig. 6]. At each educational level, men reported having more influence than women did, but the gap was narrowest among Ph.D.s. Although influence increased in tandem with educational levels, the differences between the U.S.-born and the others were not statistically significant.

To perform well in technical work, one must receive input from colleagues as well as give it; in fact, studies of scientists and engineers have firmly established that the more people they talk to, the better they are likely to perform at work. The presumption is that such contacts expose those who have them to a variety of ideas and create opportunities for refining one's own ideas [Fig. 7]. There were no statistically significant differences between the number of people with whom male and female scientists and engineers talked in an average month, but women with master's and doctoral degrees talked with more people than did women with bachelor's degrees; men, by contrast, did not vary as much by degree level. Immigrants were at a disadvantage to the U.S.-born in this respect, and the gap was greatest for those with master's and Ph.D. degrees.

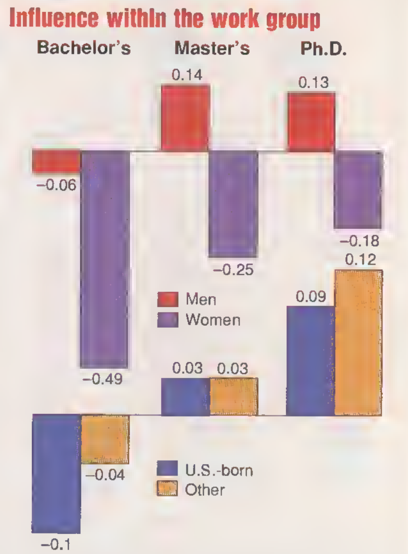
Obviously, these issues do not cover every kind of work experience that scientists and engineers encounter. Yet they are important. Previous studies of the members of these professions have found that diversity of work experience and increased communication with colleagues improve their job performance. Our study indicates that the experience of initiating new projects, involvement with work, technical control over work goals, and influence on the work group all have an influence on how a scientist or engineer is rated by managers. It is therefore important that women with doctorates (and, in some cases, master's degrees) were less likely to differ from comparable men than were women with bachelor's degrees, while immigrants with doctorates (and, in some cases, master's degrees) were likely to differ more from the U.S.-born at the same educational levels.

DIFFERENT EFFECTS. One possible explanation of education's different effects for gender and birthplace is that the proportions of the people within the subgroups who hold doctorates and master's degrees are different. Only 14 percent of the women in this study had Ph.D.s, as compared with 33 percent of the men, but 48 percent of those born outside the United States had them as against only 25 percent of the native group. In other words, women with doctorates are unusual among scientists and engineers in industrial R&D, but foreign-born holders of doctorates are quite common.

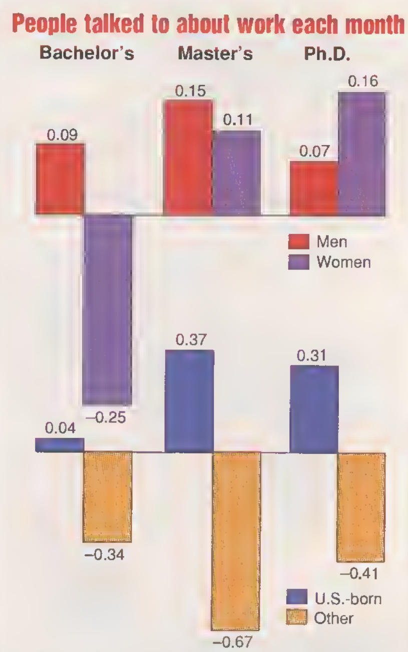
The latest statistics confirm these numbers. In 1992, women earned about 20 percent of all doctorates in the physical sciences—9 percent in engineering, 40 percent in the life sciences. People who were not citizens of the United States earned 46 percent of the doctorates in the physical sciences, 61 percent of the doctorates in engineering, and 34 percent of the doctorates in the life sciences. Although growing numbers of women have been awarded doctorates in the physical and biological sciences and in engineering, the proportions are still relatively small. For the foreign-born, both the proportions and the numbers have been rising



[5] Female scientists and engineers reported having lower technical control of work goals than their male counterparts did [top]. U.S.-born scientists and engineers reported having a higher level of technical control than their immigrant counterparts [bottom]. The numbers are deviations from a grand mean of 3.91 on a scale of 1 (low) to 7 (high).



[6] Male respondents reported having higher levels of influence in work groups than the women did [top]. Although the U.S.-born with bachelor's degrees reported having lower levels of influence than did their immigrant counterparts, the differences are not great [bottom]. The numbers are deviations from the grand mean of 4.65 on a scale of 1 to 7.



[7] Men in the survey who hold bachelor's degrees reported talking to more people each month about their work than the women did, but the difference was smaller at the higher academic levels [top]. U.S.-born respondents talked to more people about their work each month than did their immigrant colleagues [bottom]. The numbers are deviations from a grand mean of 6.76 on a scale of 1 to 10 or more people.

Defining terms

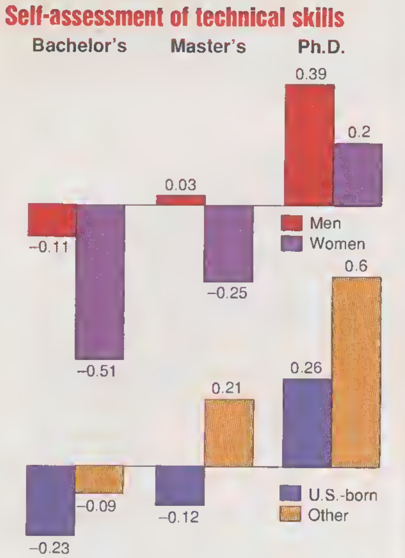
Analysis of covariance: a statistical procedure for comparing the means, or average scores, of two or more groups in a sample while statistically adjusting for differences in their composition among variables that may affect the differences between those means.

Factor analysis: a data reduction procedure to determine the pattern of correlations among a set of data items. The procedure generates a factor—a new item composed of weighted combinations of the original items. With a mean of 0 and a standard deviation of 1, this factor is measured in standard deviation units, a measurement called a "z score."

Grand mean: the mean, or average, for a whole group of data rather than the mean for a subgroup within it—say, men or women.

Standard deviation: a measure of the variance, or spread, in a set of data. In a so-called normal "bell-shaped" distribution, for example, 68 percent of the cases in the sample fall within one standard deviation of the mean and 96 percent within two standard deviations.

Variance: typically, the square of the standard deviation.



[8] Male scientists and engineers assessed their technical skills more positively than their female counterparts did [top]. Immigrant scientists and engineers assessed their technical skills more positively as compared with their U.S.-born colleagues [bottom]. The numbers, based on the analysis of several factors, such as technical ability and creativity, are deviations from the grand mean of zero, measured in standard deviation units.

rapidly. A larger proportion of the respondents in our study held degrees in the physical sciences and engineering than in the life sciences. Of course, the type of degree (science as opposed to engineering) could have more effect than the level of that degree, but the question remains: why are the effects of gender different from those of birthplace?

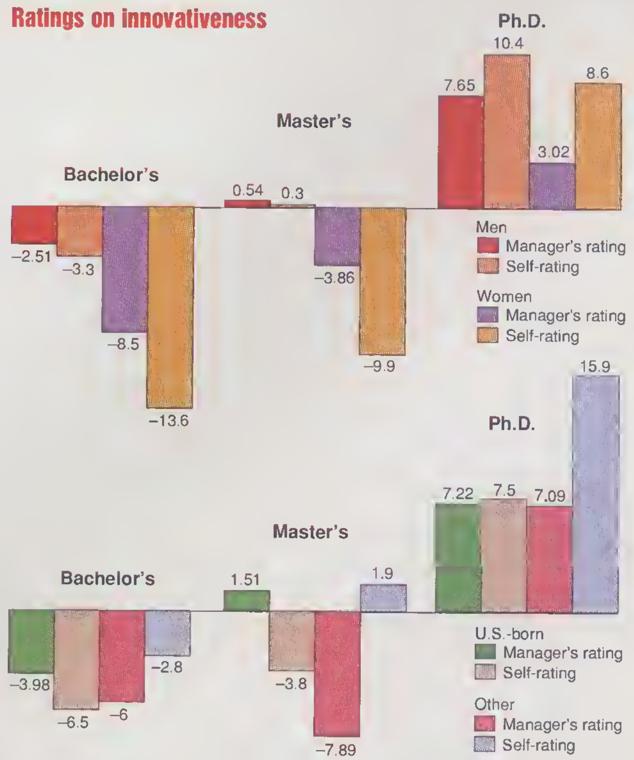
SELF-ASSESSMENT. Earning an advanced degree confirms the recipient's feeling of intellectual accomplishment and technical knowledge. Clearly, women without Ph.D.s do not have less to offer than men without them. But particularly in technical fields, women have more difficulty persuading others of their technical competence in the workplace than do men at the same educational levels. Moreover, women, especially those without Ph.D.s, are less confident about their technical abilities than are comparably educated men [see "Diversity and performance in R&D," *IEEE Spectrum*, June 1992, pp. 21–24], and this finding is consistent with those of other studies. Less has been written about the self-assessments of immigrants versus those of the native-born, but general studies of immigrants have found that they tend to value their cultures of origin more highly than they do their adopted cultures. This may have some influence on the way they perceive their technical skills, for we found that immigrants, especially those with Ph.D.s, rated those skills more highly than U.S.-born scientists and engineers rated their own.

Figure 8 shows these differences by educational level and by gender and birthplace. Overall, self-perceptions of technical skill rose with educational levels. But for women the confidence gap with men narrowed as education increased, while for the foreign-born it widened. Thus, earning a Ph.D. helped women gain confidence in their technical abilities, but there was still a significant gap between them and men, whereas earning a Ph.D. further raised the greater confidence the nonnative have in their technical skills as compared with the U.S.-born.

As for self-assessments of innovativeness—a narrower dimension of performance than technical skill—there is a gap between women and men at the bachelor's and master's levels but not at the doctoral level. For immigrants, by contrast, the gap is much wider for Ph.D.s than for those with bachelor's or master's degrees. The contrast in self-perception and the effect of having a Ph.D. can be seen especially clearly in Fig. 9, which presents the respondents' own ratings of their innovativeness and those of their managers. Men rated themselves more or less as their managers rated them, with the greatest discrepancy for Ph.D.s, whereas women with bachelor's or master's degrees rated themselves less positively than their managers did. Only women with Ph.D.s gave themselves higher ratings than their managers did, and their ratings were similar to those of men with Ph.D.s. However, the U.S.-born tended on average to rate themselves less generously than their managers rated them, while immigrants, especially Ph.D.s, rated themselves more generously.

The fact that having a Ph.D. has different effects for gender and birthplace may be related to the perceptions of others about what that degree implies. Perhaps because such a small proportion of women hold the doctorate, they enter technical fields without the benefit of the doubt. The degree itself therefore becomes an important if rather precarious symbol of technical competence. The foreign-born, at least in R&D, are assumed by others to be technically competent. Even so, their lack of diversity in work assignments, their lower technical control, and their less extensive interaction with colleagues to some extent undermines their effectiveness in the eyes of their managers.

These results certainly suggest that women are more likely to do well in R&D if they pursue advanced degrees. But we cannot assume that women who hold them will experience smooth sailing in their careers. Although a Ph.D. may enhance the status of those who have earned it, it also may require female graduate students to conform to a narrow model of behavior to be accepted as competent by male professors and colleagues. Given the large numbers of foreign-born people completing Ph.D.s in the physical sciences and engineering, they probably enter the field of R&D with the benefit of the doubt regarding their technical skills. Even so, this does not mean that their careers



[9] Both male and female Ph.D.s considered themselves to be more innovative than their managers did. They also rated themselves more positively than did scientists and engineers at the bachelor's and master's levels [top]. Immigrant scientists and engineers with Ph.D.s rated themselves more positively than their managers rated them, and more positively than their U.S.-born counterparts rated themselves. These numbers are deviations from a grand mean of 56.4 percent. The respondents were asked to estimate the proportion of those in similar jobs whom they surpassed in this respect, on a scale of 1–100 percent.

progress without difficulty. The divergence between their work experiences and those of the U.S.-born may contribute to their inability to persuade their managers to accept their own assessments of the contribution they are capable of making.

Our analysis must obviously be qualified in certain ways. The results for women are more apparent among those born in the United States than among their immigrant counterparts. The results for immigrants are more apparent among men than among women. In other words, the work experiences and self-perceptions of foreign-born women are different both from those of U.S.-born women and of foreign-born men. The number of foreign-born women in our study was too small to break them out separately as a group.

Moreover, the work experiences of foreign-born scientists and engineers from different parts of the world diverge in many ways. The tendencies reported here are most evident among Asians; people from Euro-ethnic cultures resemble the U.S.-born to a greater extent than our overall results would suggest. Scientists and engineers from Africa, Latin America, and the Middle East gave mixed responses. Again, however, when we break down the sample of foreign-born scientists and engineers both by region of origin and by educational level, the numbers in each subgroup are small. Patterns are more evident when we consider the foreign-born as a group.

To sum up, education—whether its level or type we cannot say—affects the way scientists and engineers experience their work, but its impact differs for different subgroups. For women, an advanced degree moderated differences in work experiences that were otherwise evident with men. For immigrants, an advanced degree widened the gap in perceptions and work experiences as compared with those born in the United States.

Managers of scientists and engineers should be alert to the possibility that some employees are underutilized and perhaps less effective than they believe they could be. Both self-perceptions and the perceptions of others may interact with the context and structure of employment to cause unintended results. If, for example, women must prove their competence before being treated as competent, this in itself may undermine their confidence. Likewise, nonnative scientists and engineers who have less interaction with colleagues and managers than their U.S.-born counterparts do may also have less opportunity to refine their ideas in a way that is most useful for the organizations they serve. It is not clear that these differences are a matter of choice rather than the outcome of style, culture, experience, job assignments, and levels of feedback. In other words, scientists and engineers with different backgrounds may have not only different perceptions of their experiences but also different experiences. Calling attention to these differences may help anchor our experiences and open the way for choices and changes where warranted.

TO PROBE FURTHER. "Experiencing Technical Work: A Comparison of Male and Female Engineers" is discussed by Lotte Bailyn in *Human Relations*, 1987, vol. 40, No. 5, pp. 299–312. The authors address "Diversity in the Technical Work Force: Rethinking the Management of Scientists and Engineers" in the *Journal of Engineering and Technology Management*, 1993, vol. 10, pp. 101–127. "Diversity and Performance in R&D" is at the focus of a June 1992 *IEEE Spectrum* article by Nancy DiTomaso and George F. Farris. See also *Women in Engineering: Gender, Power, and Workplace Culture*, by Judith S. McIlwee and Gregg Robinson (State University of New York Press, Albany, N.Y., 1992). The National Research Council's *Summary Report 1992: Doctorate Recipients from United States Universities* (National Academy Press, Washington, D.C., 1993) provides insights into the role of diversity. *Immigrant Scientists and Engineers: 1990* is a National Science Foundation study (No. NSF 93-317, Washington, D.C.). *Women in Engineering: Beyond Recruitment* is the focus of an investigation edited by Mary Ott and Nancy A. Reese (Cornell University Press, Ithaca, N.Y., 1975). "Caucasians and Asians in Engineering: A Study of Occupational Mobility and Departure" is addressed by Joyce Tang in *Research in the Sociology of Organizations* (Vol. 11, 1992, pp. 217–256).

"American Minorities in Science and Engineering" is the topic of Occasional Paper 92-1, by Betty M. Vetter, in *Commission on Professionals in Science and Technology* (Washington, D. C., Nov. 1992). Vetter also analyzed "Foreign Citizens Among U.S. Scientists and Engineers" in Occasional Paper 92-2 (Aug. 1992) and "What is holding up the glass ceiling?: Barriers to women in the science and engineering workforce" in Occasional Paper 92-3 of the same publication (Nov. 1992).

The management of such technical functions as research, development, and engineering in industry, government, university and elsewhere is regularly covered by the IEEE Transactions on Engineering Management. Contact: IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, N.J. 08855-1331, 908-981-0060; fax, 908-981-8062.

A relevant meeting is the 1994 IEEE International Engineering Management Conference—EM '94, Oct. 17-19 in Dayton, Ohio. *Contact: Holm Conference Registrar at the IEEE Service Center, 908-562-3895; fax, 908-562-1571.* ◆

Analyzing the data

The results presented in this article were based on analyses of covariance, controlling (or adjusting) for experience and either gender or birthplace within each educational level. This statistical adjustment allows us to compare the groups—for example, as though they had the same distribution of years of experience—and thus isolates the effects of gender from those of experience. A new or adjusted mean is then calculated by multiplying women's scores, for example, at each level of experience by the proportion of men at that level, or vice versa. The analysis of procedures reports this new mean as a deviation from the grand mean. Similar adjustments were made both for gender (in the birthplace comparisons) and for birthplace (in the gender comparisons). Because we did the analyses within educational levels, we then had to calculate the scores across them to get deviations from the overall mean of the total sample. For the charts based on factor analysis {Figs. 2, 4, and 8 in the main text}, the units of measurement are the standard deviations of the factor score; for the other charts, they are those used in the original survey items.

Statistical significance depends both on the difference in the means, or average scores, and on the variance, or spread, of the scores. Analysis of covariance is a procedure that determines statistically whether there is more variation within or between the groups being compared. If there is more variation within than between them, they are thought not really to differ. If there is more variation between than within them, they are thought to be drawn from different populations—that is, to be different. Because the level of significance is also determined in part by the size of the sample, we were more concerned for the purposes of this article with the pattern of results—for example, convergence or divergence by educational levels—than with the levels of statistical significance.

When we break down the sample both by educational levels and gender or birthplace, the cell sizes for some subgroups are small. Further, the effects are not uniform. Some issues are related both to education and to gender but not to birthplace. Some, such as the numbers of people a scientist or engineer talked to, are related to birthplace but not to gender. Finally, some, such as the assessment of technical skills, are affected both by gender and by workplace; the difference by educational level converges with gender but diverges with birthplace.

—N.D., G.F.F., and R.C.

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George F. Farris is professor of organization management in Rutgers' Faculty of Management, where he also directs the Technology Management Research Center. He is department editor of IEEE Transactions on Engineering Management *and has undertaken extensive research on the management of scientists and engineers.*

Rene Cordero is an assistant professor in the School of Industrial Administration, New Jersey Institute of Technology. His research interests are the management of technology and innovation.

IEEE
SPECTRUM

FOCUS REPORT AND GUIDE TO

ENGINEERING WORKSTATIONS AND PCs

FEATURING

WHAT CLIENT/SERVER USERS WANT ■ SELECTING LOW-COST SYSTEMS
ADDING MULTIMEDIA ■ BACKING UP THE NETWORK

Engineering workstations and PCs

A strong shift in the computing spectrum is clearly visible in this year's *IEEE Spectrum* focus report on engineering workstations and personal computers.

To begin with, there is the shift to client-server computing. Judy Larocque, the founder of the electronic market research firm, Market Perspectives Inc., Framingham, Mass., quantifies the degree of this shift. In a report based on the results of a survey of those who attended a recent conference on client-server computing, Larocque explains how users expect client-server computing to affect how they do things over the next two years. She also highlights the reasons why people are making this shift, and discloses what is needed in this rapidly expanding market.

A major reason for the client-server shift is economic. People can get a lot more computing power for their money if they use networks of workstations and PCs effectively, rather than terminals tethered to a single mainframe. So it is not surprising that there is the concomitant shift to lower-cost workstations.

Today, the cost of workstations continues to drop, while the power of PCs is on the increase. Egil Juliussen, president and editor of the *Computer Industry Almanac*, Incline Village, Nev., gives readers rules for selecting the low-cost machines that will best suit the needs of a particular group or company. Following Juliussen's article, a table created by *Spectrum* presents currently available workstations and PCs that cost less than US $7000.

While networks of low-cost computers offer many financial and operating benefits, they also pose new challenges, particularly in preventing important information from inadvertently being lost. In the past, holding onto corporate data was simpler; since all the electronic data was handled by the mainframe, its storage systems could be "mirrored," that is, two independent sets of removable-hard-disk drives could be used to copy the same information. The management information system department could then make sure that data was transferred to archival storage regularly.

Richard Comerford Senior Editor

The 700 series from Hewlett-Packard Co. puts PA-RISC and Unix computing in the hands of engineers at prices starting below US $4000.

Hewlett-Packard Co.

Entry into the workstation family of Digital Equipment Corp. now costs around US $5000. The 300LX features a 125-MHz Alpha chip.

Digital Equipment Corp.

IBM is using its power microprocessors to lower the entry price into its RS/6000 line of workstations.

IBM

But with a distributed computer system, all the essential data is not stored in one place. Even when companies use file servers to centralize and back up records, some essential day-to-day data may still reside in an individual's local workstation. So the demand for better storage backup systems has increased, shifting down to the level of backing up the hard drives of any PC or workstation on the network.

As Jim Spicer, vice president of engineering for Mountain Network Solutions Inc., Santa Clara, Calif., points out, the data storage industry has heard this call and is in the process of responding. Companies are developing new standards that will let backup systems, using magnetic or optical media, reach out and secure data stored anywhere in a heterogeneous network.

In fact, this effort may lead to a new view of system memory, one in which the user may not have to know—or care—where files are stored. Electronic information may reside locally on a workstation's hard disk, down the network on a file server, or on tape or optical media in a remote archive, and its location and access would be transparent to the user. The accompanying *Spectrum* table presents the most popular formats of tape storage systems for backup.

While still inexpensive, tape is not the only backup medium to be considered. A variety of optical and CD-ROM storage systems can fill the bill, too. Further, these systems provide a means for economically storing and accessing data in new formats—video, for instance—thereby allowing multimedia to be used in new ways. The report concludes with a brief look at the opportunities these new media offer, and provides a list of some of the most recent system offerings, including new recorders that allow even the smallest organizations to publish CD ROMs.

COVER: The Indy line of workstations, with an entry-level price of $4995, from Silicon Graphics Inc., Mountain View, Calif., raises engineering expectations of what a low-end system should be. Introduced last summer, it puts desktop video within the grasp of those with limited budgets and opens the door to peer-to-peer design teleconferencing.

0018-9235/94/$4.00©1994IEEE

Defining terms

Cache: a high-speed memory that resides logically between a central processing unit (CPU) and main memory, and holds data and/or instructions the CPU is most likely to need soon.

Client-server computing: in a distributed computer system, the performance of tasks by one or more available hardware and/or software entities in the system at the request of another entity.

Complex-instruction-set computer (CISC): a computer whose processor is designed to sequentially run variable-length instructions, many of which require several clock cycles, that perform complex tasks and thereby simplify programming [see also reduced-instruction-set computer].

Compact disc-interactive (CD-I): a format developed by Philips Consumer Electronics Co. for recording and playing interactive multimedia programs on 120-mm optical (compact) discs.

Compact disc-recordable (CD-R): a 120-mm optical (compact) disc on which data can be recorded once and read many times.

Distributed computing environment (DCE): a set of requirements and applications developed by the Open Software Foundation (OSF) as an infrastructure for systems of networked, heterogeneous computers.

Distributed management environment (DME): a set of requirements and applications developed by the Open Software Foundation (OSF) for managing distributed computing environments [see above].

Fiber distributed data interface (FDDI): a network based on the use of optical-fiber cable to transmit data in non-return-to-zero, invert-on-1s (NRZI) format at speeds up to 100 megabits per second.

Integrated services digital network (ISDN): a standard for digitally transmitting video, audio, and electronic data over public phone networks.

Multisession: the ability to record additional information, such as digitized photographs, on a CD ROM after a prior recording session has ended.

Peripheral component interconnect (PCI) local bus: a standard internal interconnect for data transfer to peripheral controller components, such as those for audio, video, and graphics [see also VESA local bus].

Personal Computer Memory Card International Association (PCMCIA) bus: a standard external interconnect that allows peripherals adhering to the standard to be plugged in and used without further system modification.

Physical address: a binary address that refers to the actual location of information stored in secondary storage.

Reduced-instruction-set computer (RISC): a computer in which the processor's instruction set is limited to constant-length instructions that can usually be executed in a single clock cycle [see also complex-instruction-set computer].

Secondary storage: storage that is accessed relatively infrequently compared to primary storage, such as cache and RAM, and is less costly.

Server: a computer that provides a network with a specialized service, such as data storage and retrieval or high-speed computing.

Small Computer Systems Interface (SCSI): an industry-standard high-speed interface primarily used for secondary storage.

SPECmarks: a normalized measure of performance, currently used for Unix systems, based on the speed with which a system can perform a standard set of operations.

Symmetric multiprocessing (SMP): a computer architecture in which tasks are distributed among two or more local processors.

Thick Ethernet (10-base-5): an Ethernet in which the physical medium is a doubly shielded, 50-Ω coaxial cable capable of carrying data at 10 Mb/s for a length of 500 meters (often referred to as thicknet).

Thin Ethernet (10-base-2): an Ethernet in which the physical medium is a single-shielded, 50-Ω RG58A/U coaxial cable capable of carrying data at 10 Mb/s for a length of 185 meters (often referred to as AUI or thinnet).

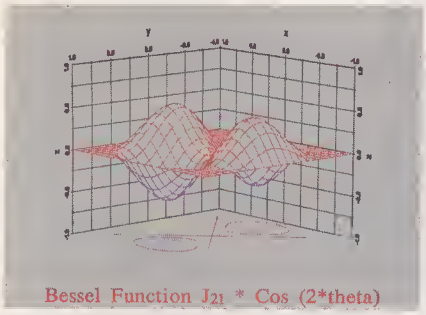
Twisted-pair Ethernet (10-base-T): an Ethernet in which the physical medium is an unshielded pair of entwined wires capable of carrying data at 10 Mb/s for a maximum distance of 185 meters.

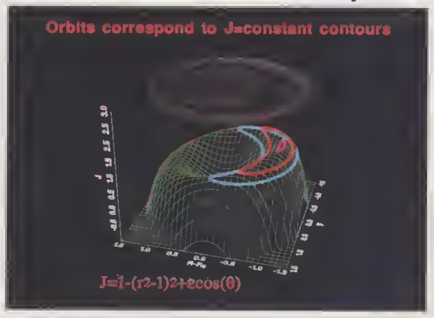
VESA local bus (VL bus): a standard internal interconnect defined by the Video Electronics Standards Association for transferring video information to a computer display system [see also peripheral component interconnect].

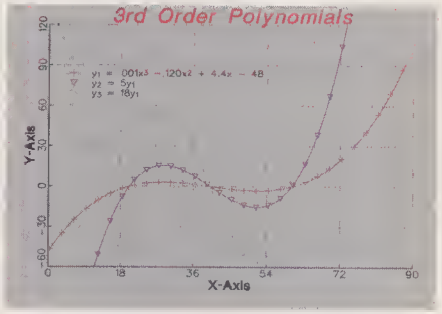
Virtual address: a binary address issued by a CPU that indirectly refers to the location of information in primary memory, such as main memory. When data is copied from disk to main memory, the physical address [see above] is changed to the virtual address.

486/Pentium Cross Platform Tools

The Fastest 32-bit Code NDP Fortran, NDP C|C++ and NDP Fortran-90







DOS

NDP Fortran has come with DOS screen graphics since it was introduced in 1987. The problem with this approach today is that just writing to the screen is not enough. You also have to be able to interface the 32-bit API that comes with your OS and possibly other API's. However, taking advantage of a single API is a time consuming tedious task.

OS/2

VGP solves the API interface problem with a universal vector output format that can be converted into EPS, TIF, GEM, HPGL2, CGM, WMF, etc. You create plots or graphics with calls to NDP Fortran or C. Included with the compiler is a DISPLAY program that runs on the OS you ordered. If you want to export your work, import PS or TT fonts or do real time screen plots by

Windows

binding **VGP** into your program, you can purchase one of several upgrades, or the source! Best of all, you get the same output independent of the OS you are using and **VGP** supports over 20 different types of plots, making it easy to create displays which communicate your ideas.

DISPLAY Export Extensions..................$145
Binary/C Source library................$395/695

386, 486 & Pentium Compilers

Microway's NDP family of 32-bit compilers generate globally optimized mainframe quality code that runs on the 386, 486, Pentium and i860. They run on 32-bit operating systems such as OS/2, UNIX, Solaris, Coherent, and DPMI/VCPI DOS Extenders.

NDP Fortran-90™ a complete Fortran-90 which runs in conjunction with the NDP Fortran.

NDP Fortran™ is a full F77 with F66, DOD, VMS and MS extensions.

NDP C|C++ compiles K&R and ANSI C plus is C++ Release 2.1 compliant.

NDP Pascal™ is a full ISO Level 1 Pascal with BSD extensions that can interface the NDP C runtime libraries.

NDP Language Pricing

DOS versions include a VCPI/VM DOS Extender, DPMI interface layer, support for x87 and Weitek coprocessors, NDPLink, NDPLib and **GREX** - our DOS graphics library. The Pentium release adds new code generation, royalty free DPMI and VCPI plus symbolic debugging.

DOS 386/486 version...........................$695
DOS Pentium version............................$995

OS/2 Developer's Pack includes IBM OS/2 WorkFrame and Toolkit. These tools use the IBM Linker. Deduct $100 if you don't need the Workframe. 386/486.................................$595
Pentium...$795

UNIX 386/486 use the native tools and are available for **SCO** or **ISC** UNIX.............. $1195
Coherent version...................................$295
NDP Fortran-90..................................$395

i860 Supercomputers

Gigacube™ - Your choice of QuadPuters or ArrayProXPs - a Gigaflop starting at.......... $50K

ArrayProXP™ - EISA Array Processor - features a zero wait state 50 MHz 64-bit memory system. The 400 MB/Sec memory bandwidth in conjunction with 100 megaflop i860XP results in 28.96 Linpack megaflops, 94 megaflops doing dot products and 70 megaflops doing FFTs. The card bursts on the EISA bus at 33 MB/Sec and holds up to 256 megabytes of RAM from $7995

QuadPuter™**-860** - The world's most cost effective Supercomputer. The QuadPuter includes four modules, each containing a 25 MHz i860 and two megabytes of local memory. The modules plug into an EISA card that provides 32 megabytes of shared memory. A single QuadPuter has an aggregate throughput of 200 megaflops! With software from..... $9995

Number Smasher™**-860** - our ISA 860 card comes with 8 or 32 megabytes. It includes an NDP Language - 80 megaflops of throughput starting at just.........................$2995

NDP Fortran™**-860** along with our C|C++ and Pascal utilize advanced scalar code generation techniques to optimize the i860's numeric scalar performance..........$1995

PPS™**-860** postprocessing scheduler, takes assembler output and converts scalar operations into pipelined operations running in dual instruction mode. Scalar speed ups in the range of 10 to 50% are common.............$500

VAST-II Vectorizer speeds up vector codes 100 to 300%. Includes a library of 700 vector primitives...$1495

Pentium/486 Workstations

486-BX Workstations - a Microway Tower is the ideal solution to your 486/Pentium needs. They feature industrial grade American power supplies, heavy duty cooling and easy access. All motherboards are carefully burned in and equipped with 50 Amp connectors. Some of our motherboards can be upgraded or purchased with Pentiums. Our BX Towers make great Workstations, file servers, and CAD/CAM stations. They were originally engineered to house i860 arrays, configured as NFS computational servers. Each system is customized with the OS of your choice, including ISC UNIX, OS/2, DOS and Windows. What differentiates Microway towers is our ability to integrate the peripherals you need, including SCSI tape drives and CD-ROMs, network cards and high quality hard disk and graphics adopters. 486-BX systems are used worldwide performing demanding tasks from testing jet engines to searching for oil. Call today for our BX Catalogue.

Search Engines & Libraries

MSE-160 - Free Text Search Engine ISA card processes 160 megabytes of data per second. Includes Text Retrieval software....................$950

IMSL Microway compiled and validated version of the IMSL mainframe libraries, available for the 386/486 or i860, Complete Package..$2,000

NAG Microway compiled and validated
Foundation x86/i860.........................$1195/1995
FortLP..$1195/1995
Workstation......................................$2995/3995

KUCK & ASSOCIATES hand coded i860 libraries. DSP library does 1024 real FFT in 500 microseconds!
DSP......................$750 BLAS......................$500

LAPACK and BLAS, sources included.
386/486................$195 i860......................$295

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Circle No. 208

Client-server trends

The call is out for software developers and information system managers to support the move to mission-critical client-server applications

Last December in Chicago, during the week of the Database World and Client-Server World show, 683 of those in attendance were surveyed for their opinions on client-server computing and their preferences in this area. Their responses reflected a multifaceted market—one that is driven by a universal desire for greater programming productivity—and showed that opportunities still abound for developers to seize with previously unthought-of products.

As evidenced by the survey, database application development and client-server computing are centered in the vertically integrated industries, which supplied 52 percent of the attendees sampled. Software vendors and computer manufacturers, which provide client-server products, made up only 15 percent of the respondents. Attendees were evenly distributed across small, mid-sized, and large organizations.

All sizes of organizations, especially those with mainframes, are investing actively in graphical user-interfaces (GUIs) and desktop reporting tools. Connectivity, including distributed database access and client-server management tools, is also in high demand, proof being that half of the attendees are willing to pay US $20 000 for an open systems database server.

Judy Larocque Market Perspectives Inc.

All the same, more than one-third of those surveyed do not currently use client-server applications, largely because they are reluctant to accept them. Still, all but 1.5 percent of the attendees expected to be using such applications by 1995.

The attendance of so many end-users of client-server hardware and software marks the technology's graduation from the early adoption stage, when the percentage of suppliers is much larger. Client-server is now in daily use at many corporate data centers and in every sector of industry. Fifty-two percent of the attendees sampled came from commercial, noncomputer industries, with manufacturing leading the way at 13 percent.

These respondents were users of technology and represented the bulk of the buying population present at the conference. Consultants, who often sway large purchase decisions, formed 12 percent of the show attendees.

MORE PRODUCTIVE. Those organizations that are assimilating the technology, whether small, mid-sized, or large, are doing so in order to improve the productivity of those writing software. As many attendees came from small firms, of at most 100 employees, as came from large companies employing over 500; each accounted for about 37 percent of the total. Mid-sized organizations make up the difference.

The larger the average size of a group of organizations, the greater the ratio of user organizations to providers. Around half of the small firms represented in the survey provide technology. In mid-sized firms, users constitute 79 percent of the respondents. The proportion of end-users grows to 85 percent in large firms. The results indicate that these large firms are eager to minimize their dependence on mainframes by exploiting client-server computing in heterogeneous, company-wide networks.

ENVIRONMENTS. Seventy-six percent of the sample of conference attendees said they used the PC as their primary desktop platform and Windows as their primary desktop operating system. They preferred Windows by more than 2:1 to the next most popular, DOS.

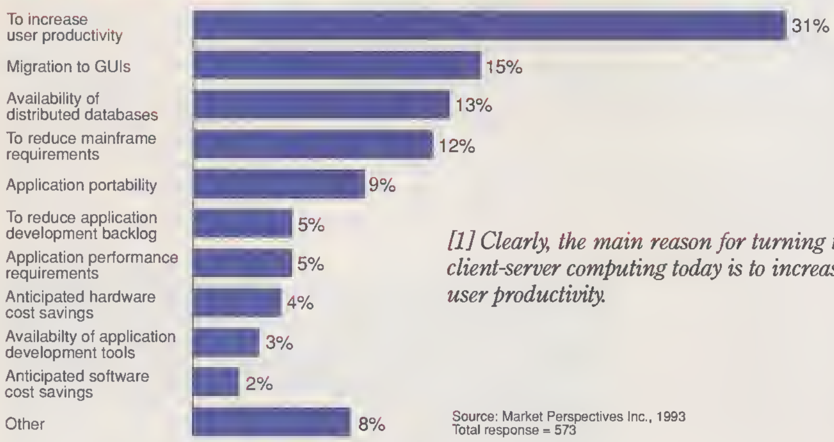
PCs have also become the top choice for server platforms, being used for this purpose by 40 percent of the respondents. Systems running some version of Unix—which includes computers from Sun, Hewlett-Packard, Digital Equipment, NCR, Sequent, and Silicon Graphics—are the favorite server of 23 percent of those surveyed. Mainframes and AS/400s, while numerically few as primary server platforms (roughly one in eight and one in thirteen, respectively), support many users. Evidently, data center managers are using commodity PC technology as mission-critical data servers—that is, servers essential to a company's well-being—proving a willingness to trade off product sophistication and systems services for price and ease of use.

Networks are the lifeline, as it were, of the client-server computing environment. For half of the sampled show attendees, Novell's was the network architecture of choice. Well behind came IBM at 21 percent, with all others falling well below 10 percent.

Networks need to be managed. The five most important issues here comprised: network performance, data access and distribution, internetworking, finding skilled support staff, and open database connectivity. Considered less important by far were network management, security, remote systems management, cost-effective terminal management, and protocol integration.

Information on today's most popular mission-critical data stores and PC databases was also collected. Responses varied by industry and company size. No definitive pattern emerged for database usage, but for mission-critical data, 38 percent said they used the leading relational databases, and 24 percent used flat files and hierarchical data-

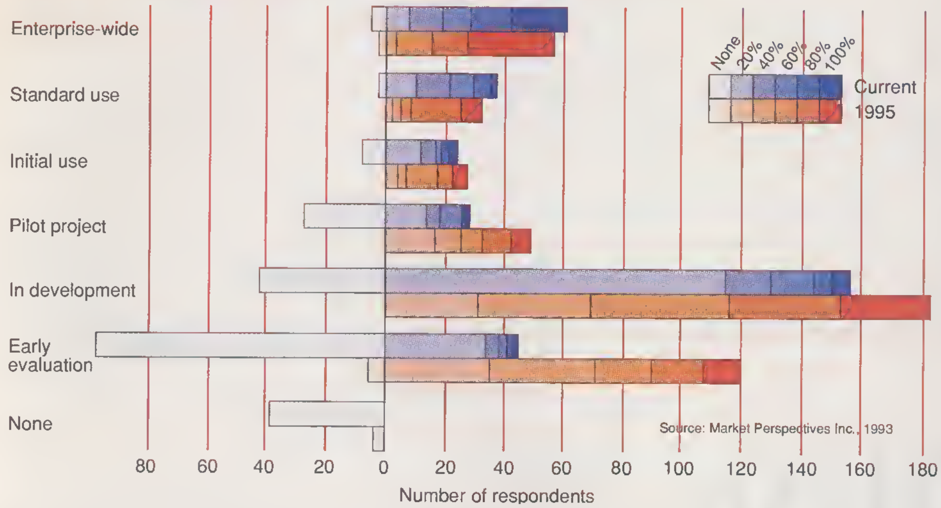
Top 10 reasons for going to client-server computing



[1] Clearly, the main reason for turning to client-server computing today is to increase user productivity.

Source: Market Perspectives Inc., 1993
Total response = 573

Use by companies today and by end 1995 (projected)



[2] In a recent survey, attendees at a client-server computing conference said that they will be heavily involved in the first phases of such computing in two years. Advanced users—those who now have standard and/or enterprise-wide applications—expect to have a lot more by then.

bases. On the PC, no single database supplier has taken the lead in handling client-server information. Thus there are still opportunities in this important area for aggressive marketing.

Client-server computing is no longer a passing fancy. Information system managers, developers, and users have shifted their focus from introductory questions to implementation issues. Sixty-two percent of the companies surveyed were currently using client-server applications at some level.

REASON TO MOVE. There are compelling reasons to move to client-server computing [Fig. 1]. Two respondents out of three selected improving user productivity as their strongest motive, followed by the desire for GUIs. Software cost-savings and the availability of application development tools, however, counted for little with respondents.

The decision to move to client-server computing may originate anywhere in a company. Thirty-seven percent of the time, a cross-functional team takes the lead. When end-users are behind the decision, migrating to a GUI is as important as increasing user productivity. If information system management is responsible, the appeal lies in gains in user productivity, shrinking mainframe needs, and corporate access to distributed databases.

Senior management, when pushing for client-server computing, reckons in hardware cost-savings. Independent software vendors and computer manufacturers see migrating to GUIs and availability of distributed databases as the key reason for their customers to move to client-server computing by buying their products.

Taken as a whole, these findings suggest that application developers involved in building client-server solutions should invariably emphasize the user productivity features, especially GUIs. Delivering features with high visibility will reinforce the system's value to the end-user.

Those surveyed were asked to describe how their company used client-server applications. The questions were: "How would you describe your company's use of client-server computing?" and "What percent of your applications would be considered client-server applications today, and in two years?" The results are shown in Fig. 2.

Virtually all respondents currently developing and using client-server applications expected to have at least 20 percent of their applications in this mode in two years.

Ninety-one percent of the attendees who did not currently use this kind of computing expected to see at least 20 percent of their applications moving to it in the next two years. [In the figure, this can be seen by the shift from the first graph to the second: the black bars, indicating no use of such applications, are replaced by those with fill patterns indicating increased usage.]

Client-server computing techniques will become the operating standard for corporate data centers within the next two years. Application developers should expect this market requirement to soar as company use moves from evaluation and development phases into initial, standardized, and enterprise-wide use.

KEY FEATURES. The survey quantified responses to the question "During the next year, I will deploy database applications with these features." Using a pen-computer's display, attendees adjusted a graphical slider to indicate their rating for each feature. The slider positions were: strongly disagree, somewhat disagree, neutral, agree, and strongly agree. Each slider position was converted to a 200-point scale, ranging from −100 to 100. This was used to precisely calculate opinions and detect subtle differences among groups of responses.

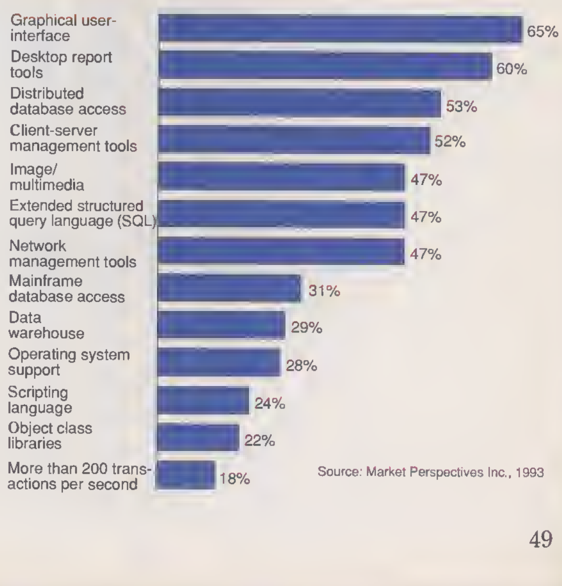
As every feature listed in Fig. 3 proved desirable, the mean score was positive. Topping the list were GUIs, desktop tools for generating reports, distributed database access, and client-server management tools. As for image-multimedia database support, extended support for structured query language (SQL), and network management tools, respondents rated these features in a statistical dead heat, implying a strong interest in using these capabilities when deploying applications.

Purchase decisions are complicated by the many factors they often involve. Factors that also interested respondents were mainframe database access, protected multitasking 32-bit operating systems, and data warehouses for legacy data, as well as support for end-user scripting languages (Xbase, Basic), object class libraries, and a transaction-processing rate in excess of 200 transactions per second.

All the features listed were rated positively by attendees. The ranking of their preferences shows that data center professionals and database users are drawn to features that increase user productivity (GUIs and report generation tools) and connectivity (access to distributed data and client-server resource management).

BARRIERS. While increasing numbers of data centers are adopting client-server technology, there are still barriers to its acceptance

Client-server and database feature desirabilty



[3] To potential users, the most important feature that client-server software should have is a graphical user-interface (GUI), but desktop report-generation tools are a close second. Very high transaction-processing speeds and the availability of object class libraries are not current concerns.

and adoption for commercial use. This is especially the case in mission-critical applications that impact the core of a business. And while the list of barriers is still led by organizational issues, product-related concerns today also rank high.

In response to the question "In your company what is the biggest barrier to increased use of client-server computing?", one in three of those who took part in the survey named nontechnical issues.

Organizational acceptance outpaced all other reasons, garnering the votes of 24 percent of all who responded to the survey. Lack of perceived advantage followed with 11 percent of the votes. Both of these issues are tied to an organization's ability to change.

Among all those who answered the question, 53 percent said that product-related issues were barriers too. The two most important were lack of training (especially in large organizations) and price. A lack of standards, the immaturity of tools, and noninteroperability were other factors seen as impeding client-server acceptance.

USER PROFILES. The survey also indicated that those most likely to purchase client-server products and services are corporate executives, management information system (MIS) managers, and database analysts. Each group, naturally, has its own set of motivations and preferences.

In small and mid-sized companies especially, corporate executives frequently make purchase decisions. They tend to be motivated by business benefits, including improved user productivity and enterprise-wide data access. Cost-savings (both hardware and software) are secondary to productivity gains.

MIS managers make the ultimate purchase decision in most large companies and need detailed capability information about client-server products. They are achieving their corporate profitability goals by enhancing users' efficiency through investments in technology. Connectivity is also important to reaching their goals.

Database analysts are chartered with the actual client-server implementation, and they deal directly with the end-users. They, too, are concerned with user productivity. They put extra emphasis on application portability and the need to reduce their application backlog. Solution-specific information is highly valued by this group.

PROGRESS TO DATE. Client-server computing has outgrown its early adopters and moved into data centers. Corporate executives as well as database professionals are transferring mission-critical applications to this new environment.

According to December's study, the proportion of attendees using client-server applications will increase from 62 percent to 99 percent in the next two years. Organizations with more than 5000 employees have the greatest investment and strongest interest in client-server solutions. However, data center managers still have to fight impediments to organizational acceptance. End-users, vendors, and consultants have quite different views of client-server computing.

The client-server market is surging ahead, especially in the case of products that enhance ease of use and the ability to interconnect different groups and tasks. The PC has now reached the desktops of 76 percent of the show's attendees, and represents a key market for client-server providers.

Figuratively speaking, client-server technology is providing the glue that binds mainframes to the new distributed data center, and firms with mainframes are willing to spend the most on client-server products and services. To all appearances, client-server computing will be vigorous in large companies with mainframes and in small firms using PC servers. As examples of successful client-server applications accumulate, market acceptance and an insatiable appetite for user productivity will stimulate future growth opportunities. ◆

ABOUT THE AUTHOR. Judy Larocque is president of Market Perspectives Inc., Framingham, Mass., a market research firm. She instituted the use of pen computers at trade shows to take snapshots of rapidly changing markets, thereby letting her firm provide real-time market intelligence to its client base.


64-Bit CISC
32-Bit CISC
64-Bit RISC
32-Bit CISC

Which low-end workstation?

The choice of an inexpensive unit has grown harder, requiring qualitative and quantitative analysis of technical and business data

A few years ago, the distinguishing features of low-end workstations were straightforward, relatively few brands and models were available, and the units were needed almost exclusively for engineering and scientific applications. Today, the increasing overlap between workstations and PCs has blurred the picture.

In the past, selection was easier in part because its outcome would in all likelihood barely impinge on a company's other computing structures. The decision, primarily an engineering one, depended mainly on performance and price comparisons.

For most companies today, the choice of a workstation affects their whole information systems structure. As client-servers evolve from their current "plug and pray" phase to the desired state of "plug and play," the selection of a workstation will become even more crucial to corporate computer strategies. Although the focus here is on entry-level, single-user units, it should be noted that, for most buyers, the server function is also becoming an important consideration in selecting a workstation architecture.

A workstation is defined today as a single-user computer with at least a 32-bit operating system, a 32-bit processor with built-in or added floating-point capability, 8 megabytes of RAM and 250 MB or more of hard-disk storage, high-performance graphics and display, and built-in networking. The entry price of these units ranges from US $3000 to $5000. Configured systems fall between $4000 and $8000, but will extend to $20 000 in some cases.

Portable products, too, are looming ever larger—especially notebook computers. Many build on Intel Corp.'s 80486 microprocessors, and Pentium-based versions are starting to appear as well, giving the Intel architecture an advantage. A few portable computers based on Sun Microsystems Corp.'s Sparc and MIPS's R4000 architectures have come to market, but only from small vendors. The PowerPC, jointly designed by Apple, IBM, and Motorola, will undoubtedly appear in portable computers by year-end.

Egil Juliussen Contributing Editor

Workstations based on Motorola's 680x0 and 88000 are not discussed in any detail here. While 680x0-based models dominated the industry in the late 1980s, they rapidly lost their place as products based on reduced-instruction-set computer (RISC) architectures became available. Backward compatibility with existing 680x0 workstations and application software is the only reason to buy more of the same today. As for the 88000 RISC processor, it arrived on this scene only after all the major workstation vendors had chosen their RISC architecture. There are currently several competitive 88000-based server products, but even in this segment it will be an uphill struggle to remain viable.

The good news about selecting workstations is that, thanks to the open systems orientation of the industry, there are no wrong choices. In contrast with the situation in mainframes and minicomputers, it is easy to migrate from any workstation vendor or architecture to a competing one. In fact, the workstation industry is now becoming even more open and the cost of switching will decline. PC vendors are even easier to switch because of the shrink-wrapped software base in the Intel-compatible market segment.

While there are no wrong choices, however, there is seldom a single right one either. But some choices are usually better than others—especially in hindsight. The key criteria for choosing low-end workstations involve five issues: longevity, technology, applications, cost, and corporate needs.

SURVIVAL. The burning economic issue is which workstation architectures will be the long-term leaders, or at least survivors. A company that invests in what proves to be a short-lived architecture must start over with another architecture, much to the detriment of its business.

Predicting the long-term viability of the various workstation architectures is somewhat subjective, but guidance is available from current trends. The factors shown in Fig. 1 should help readers in their attempt to pick the winners.

Above all, the price of the microprocessors on which a workstation family is based should fall steadily, and the processors' technology should improve continually. A large installed base and strong sales growth promote this goal by swelling the revenue base of the semiconductor and system vendors. That means they can afford healthy R&D expenditures on next-generation microprocessors and computer systems. It also means a decline in the price of microprocessors and hence the entry-level system price, so that the potential market expands.

As the number of users grows, so does the infrastructure. A large installed base and an accelerating sales rate are most attractive to third-party software and peripheral support. To turn readers into users and vendors into advertisers, magazines cover the workstation, spreading information that stimulates the improvement of the architecture. Trade shows and user groups further disseminate the news. Associations or consortiums that promote the architecture draw more vendors to it. The need for an infrastructure of this complexity often is ignored or fails to receive enough vendor support.

MISSING LINKS. Sometimes also overlooked is the need for diverse distribution channels. The availability of independent resellers matters especially to third-party software and peripheral companies. Many of them are start-up or small operations that must rely not only on the infrastructure to spread the word about their products but also on independent resellers to deliver their products to users.

To succeed today, any new architecture must be open—but open means different things to different groups. To potential system vendors, it suggests that the architecture's evolution is in the hands of a neutral party. Otherwise, the playing field is not level for other potential system vendors, and most will not participate. Note that control of the architecture by a single semiconductor vendor, while a drawback for market entry, is acceptable for an established market.

Openness can also determine the success of an architecture by inducing system vendors to enter the market—especially if they are small. All system components must be readily available, preferably from multiple sources. There must be no or minimal licensing fees, and compatibility and compliance information must be well defined and simple to implement. Easy market entry counts even more heavily with third-party vendors. A competitive market attracts the end-users. While vendors do not like intense competition, which can be hazardous to their profit margin, buyers love it. There can be little doubt that a competitive market is a long-term one.

For a new workstation architecture, the

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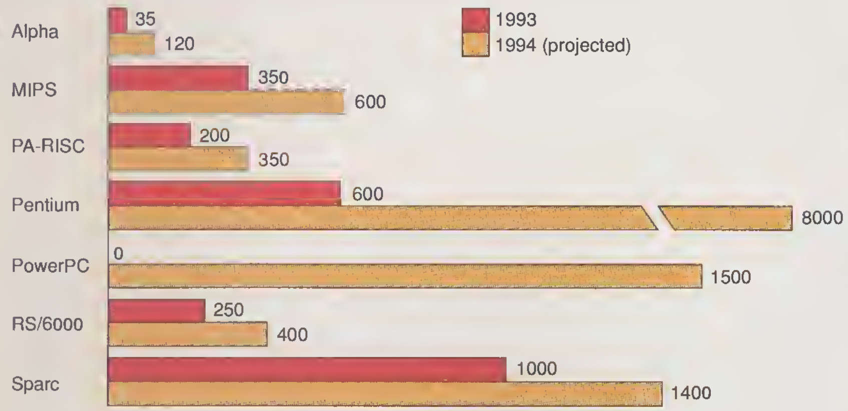
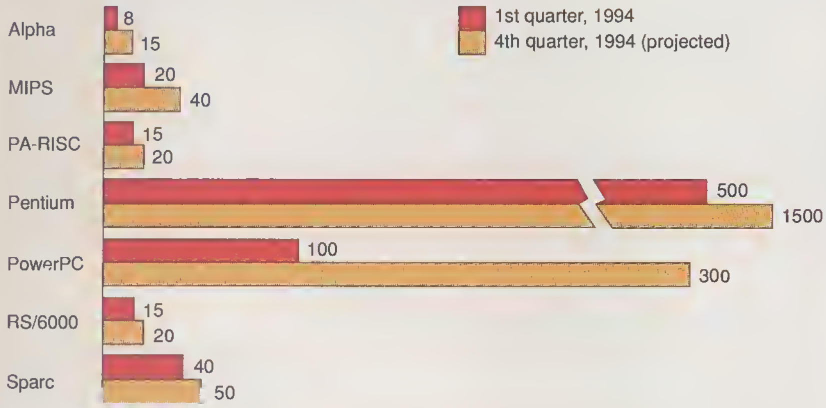
Business factors

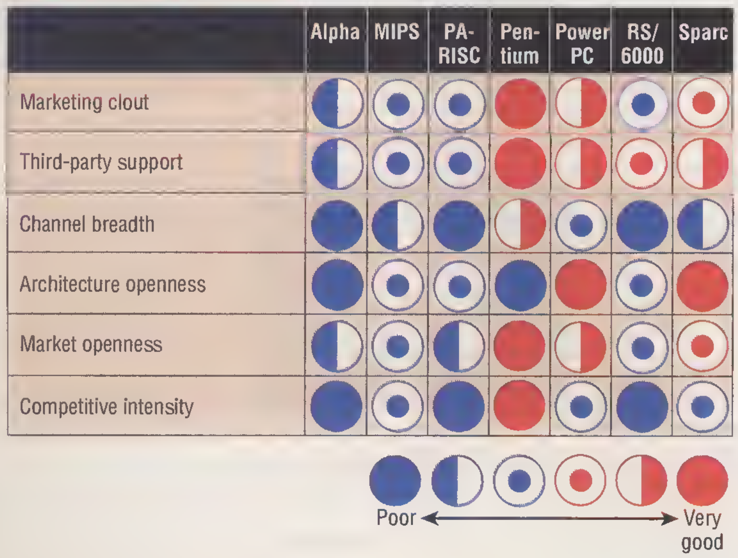
Installed workstation base by processor type, thousands of units



Monthly processor sales, thousands of units



Other business factors



[1] While most workstations today are based on the Sparc architecture, the Pentium architecture has a built-in acceptance due to the installed Intel X86 base and will likely surpass it in the near future; monthly sales of Pentium chips already far outnumber Sparc. With Apple Computer Inc. beginning to deliver PowerPC-based systems, that processor's monthly sales volume will likely exceed Sparc's, too.

bigger the market clout of its vendors, the better its chances of success. Also, the perceptions of an architecture created by the trade and financial press and by market analysts and opinion leaders are very influential, albeit intangible. They can do a lot for a solid product and can have a snowball effect on a really good one. But good perceptions can never rescue a bad product.

CANDIDATES. No comparison of the variegated workstation architectures can be wholly impartial, because much of the required information is unavailable or difficult to quantify fairly. What's left is qualitative inputs, informed opinions, common sense, historical perspectives, and reasonable projections for the future.

The installed base and monthly sales rates are key indicators of the staying power of workstation architectures. The installed base of all computers everywhere topped 165 million at the end of 1993.

Worldwide estimates for six workstation architectures appear in Fig. 1 at left. The PowerPC architecture and the RS/6000 architecture on which it is based get separate entries, but in the near future they will merge. With regard to Intel's new Pentium processor, it should be remembered that over 80 percent of the computers in use are X86 based. Current worldwide monthly sales of 386/486/Pentium-based computers fall in the 3 million to 3.5 million range.

From Fig. 1 it is clear that for the foreseeable future, the Intel architecture will remain the volume leader (even excluding embedded controller applications, as is done here). As 32-bit operating systems enter the mainstream of the PC industry—OS/2 and Windows NT today, and Windows 4.0 in 1995—the traditional workstation market and especially its low-end segment will experience fierce competition from PC-based products.

Sparc was first on the scene and is first in the workstation market. It has an installed base of nearly one million units—three to four times the figures for its later-off-the-mark competitors—and the highest monthly sales rate, albeit by a small margin. The Sparc sales rate and installed base figures—already dwarfed by the 486 DX and soon to be overtaken by the Pentium—may also be quickly surpassed by another RISC processor, the PowerPC. But if Sparc could sign up a volume application or two, it might compete with the last chip's growth. In any case, both the X86 and PowerPC architectures emanate from the PC market and will give the RISC workstations more competition than they can handle—mainly at the low end at first.

For long-term success, the vendors supporting a new computing architecture must have clout in the right market segments. This was a big factor in the weak showing of the 88000; no vendors in that camp had enough power in the workstation market to establish the processor as a major player. Conversely, the combined marketing clout of Apple Computer Inc. and IBM Corp. will make the PowerPC successful in both the PC

and workstation markets.

The marketing power of Digital Equipment Corp. rates well in the workstation market but is limited in its PC counterpart. Today, the distribution channels of Alpha products are narrow in the extreme, and their only supporter of weight is Olivetti SpA, in the European market. For Alpha to make any headway against formidable competitors, Digital must sign up more companies with market presence and high volume. The company's strategy of embracing both Windows NT and Unix is bound to strengthen third-party support.

Alpha's architectural evolution, being tightly controlled by Digital, is closed. This is unappealing to vendors because open evolution is crucial if a new architecture is to thrive. The Alpha software market is sufficiently open, but not the hardware market. As a result, Alpha may become a potent niche market but fail to rank among the volume leaders.

PROSPECTS. The problems of the PA-RISC architecture are similar to the Alpha's, except that the PA-RISC entered the market much earlier and has gained more ground. PA, too, needs more vendors with market clout to become a high-volume product. By and large, it is a workstation and midrange architecture selling only a few hundred thousand units a year. After Hewlett-Packard Co., Hitachi Ltd. is the chief market heavyweight—mostly in Japan. The PA's third-party support is respectable and should improve when the Windows NT base becomes available. But the breadth of the PA's distribution channel, though better than the Alpha's, still looks too limited to support the growth needed by a future volume leader.

The PA's architectural evolution is more open than the Alpha's, since it is backed by a consortium (the Precision RISC Organization, or PRO); but its future is still mostly driven by HP. The PA market is open only to selected vendors, for the organization wants to manage the competitive environment. By design, its members do not compete head on but have complementary products. All things considered, in the long term the PA architecture could well enjoy a comfortable niche market, starting with workstations and servers and ascending through midrange systems all the way up to mainframes and supercomputers.

The MIPS architecture looked like a winner a few years ago, when the Advanced Computing Environment (ACE) consortium had the backing of numerous vendors, including potentially high-volume ones like Compaq Computer Corp. The ACE consortium has disbanded, and many supporters (including Compaq) reverted to the X86 architecture alone. Digital, another ACE consortium member, was once the leading user of the MIPS architecture, but is now moving its sales to its Alpha-based products. Silicon Graphics Inc. is currently the main vendor, with particular strength in graphics-intensive applications. But that company's unit shipments are small—less than 50 000 in 1993.

Still, the MIPS architecture could become a long-term leader, particularly since its usage prospects are beginning to improve. The second most significant MIPS vendor, NEC Corp., is a leader in the Japanese market and has sensible presence in the United States. Sony, too, has committed to MIPS, not only for workstations but for high-volume consumer applications as well. Several start-up companies, such as NetPower and Deskstation Technologies, are also betting on the Windows NT/MIPS platform. In addition, the MIPS architecture has done well in embedded controllers, with yearly shipments in the 500 000-plus range. This could give the MIPS chip the aggressive pricing that breeds a competitive system market.

If the MIPS architecture is to have a shot at becoming a volume leader, it must find a vendor or group of vendors that requires a few million units a year. Silicon Graphics has made an agreement with Nintendo Co. that could become such a volume application. Nintendo will introduce arcade games using the R4X00 in late 1994 and follow up a year later with a video-game system for the home. If these products succeed, the MIPS architecture will join the ranks of the volume leaders.

TECHNICAL ISSUES. Good technical specifications are a necessary—but not a sufficient—condition for success. A minimum requirement is technical equality with competing architectures.

A workstation's most worthwhile technical attribute is its ability to run users' applications. Since these vary from user to user, there is tremendous confusion over the conflicting claims about the benchmark programs used to measure performance. To paraphrase Mark Twain, there are lies, damn lies, and benchmarks. Despite the clutter, some benchmarks can supply a realistic perspective on a product's typical performance.

Of the many classical benchmarks, most have only limited value. The best-known—the million-instructions-per-second (MIPS) rating and its companion, millions of floating-point operations per second (Mflops)—are of only slight use. Other classic benchmarks are: Whetstones and Linpack, which measure floating-point performance; Dhrystones, which measure integer performance; and Savage, which tests scientific math functions. All are quite narrow in their scope and should be used only in conjunction with more balanced and comprehensive measures.

Over the past five years, fortunately, a few solid benchmarks have been developed. The most important are the SPECmarks, defined by Standard Performance Evaluation Corp. (SPEC) and administered by the National Computer Graphics Association, Fairfax, Va. Most workstation vendors are members or supporters of SPEC. The SPECmarks—a suite of programs designed to perform particular types of math functions—measure integer and floating-point performance. The first version (SPEC89, introduced in 1989) provides a single-number rating that combines integer and floating-point performance. The second version, introduced in 1992, splits the integer and floating-point performance into two numbers—SPECint92 and SPECfp92, respectively. The higher a SPECmark number, the better the workstation's performance.

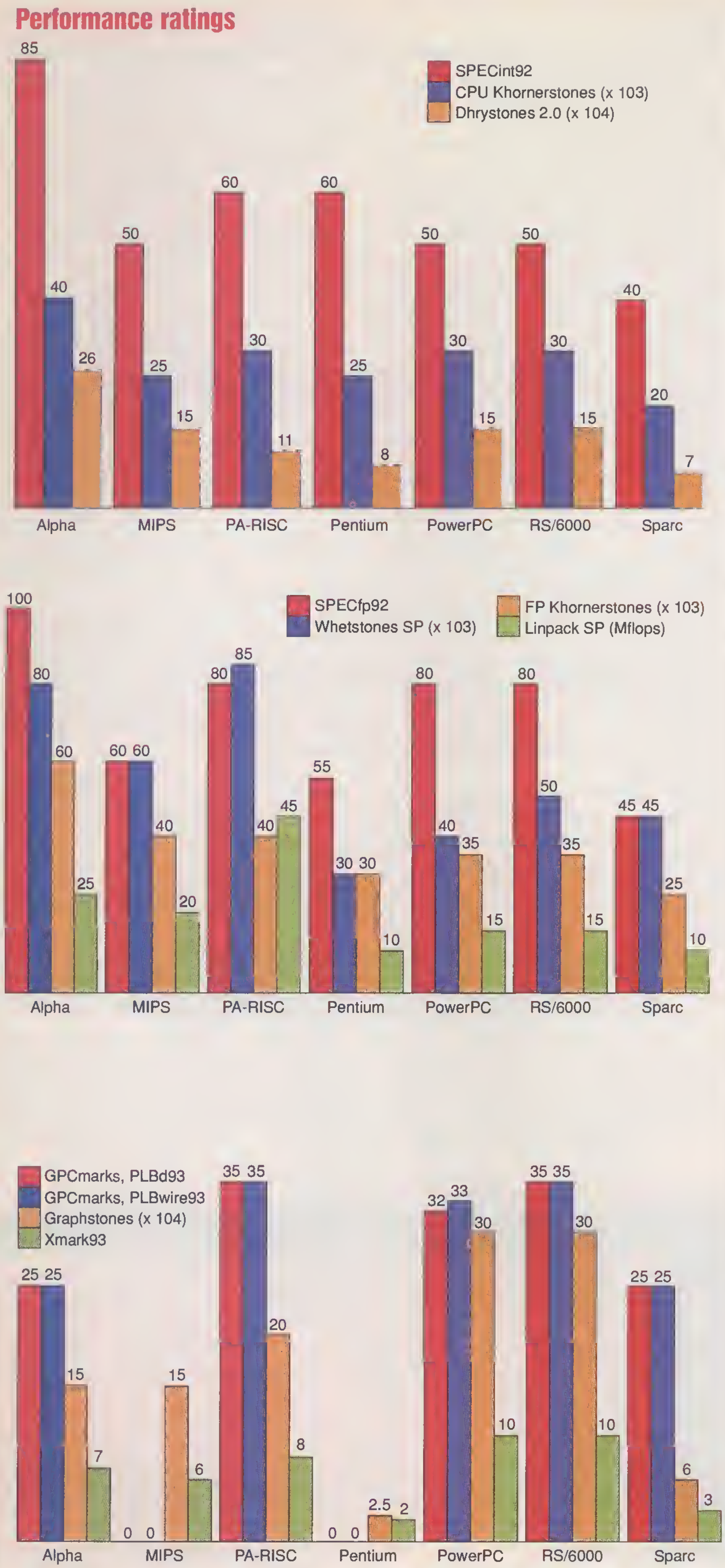
Today the three SPECmarks are the most commonly used measures of workstation performance. The benchmarks now run only on Unix operating systems, but are expected to become available for other operating systems—probably Windows NT first—in the near future.

The Khornerstone and Ghraphstone benchmarks, defined by Workstation Laboratories in 1986, have been used to test hundreds of workstations and PC models. The Khornerstone tests include measures of CPU/integer and floating-point performance. The Ghraphstone benchmark, which tests the low-level elements basic to most high-level two-dimensional graphics functions, measures the graphics library's efficiency no less than processor performance and graphics hardware capabilities.

Graphics performance lacks a clear metric leader. The Graphics Performance Characterization (GPC) Committee has defined a set of comprehensive benchmarks called GPCmarks. The nine software programs can

Typical workstation product line

	Product	Prices, in US $ thousands	Special features
Workstations	Notebook/portable	4–12	Battery operation preferred
	Entry level	4–10	CD ROM
	Low-end	7–20	Multimedia features
	Midrange	15–35	3-D graphics features
	High-end	30–60	3-D graphics accelerator
	Superworkstations	50–100	Virtual-reality graphics
Servers	Low-end	5–12	Extra cache memory
	Midrange	10–20	Multiple disk drives
	High-end	18–35	Support for symmetric multiprocessing (SMP) and redundant array of inexpensive disks (RAID)
	Superserver	30–60	Fault-tolerant features



[2] The maximum integer [top], floating-point [middle], and graphic [bottom] performance of low-end workstations is commonly measured by a variety of benchmarks.

be used on a variety of systems, including PCs and workstations. However, their use has been hampered by the difficulty of porting them to today's great variety of graphics libraries.

A recent set of graphics benchmarks—Xmark93—is based on a workstation's X11 (X Window) performance. Xmark93 is the ratio between the geometrically weighted mean of 447 different tests conducted on a given computer, and the corresponding results for a Sun SparcStation 1. As the popularity of X Windows has grown, these benchmarks have also flourished, since they are relatively easy to port to different graphics platforms.

There are no generally accepted standards for assessing disk performance, but the traditional measurement of sustainable disk transfer rates is still a reasonable performance gauge.

Fig. 2 at left compares the performance range of workstations as measured by some popular benchmarks. Benchmark performance is very dependent on actual product configurations, including processor clock rate, memory size, cache memory size, compiler versions, compiler settings, graphics hardware, graphics library, disk speed, disk interface, and operating system versions.

The performance numbers in Fig. 2 show maximums for each architecture and come from estimates for the second half of 1993 and the first quarter of this year. The figures are based on Workstation Laboratories' testing, but some of the data is derived from vendor claims. The GPCmarks are based on data from GPC: the two-dimensional picture-level benchmark, PLB2d, is a benchmark for planar graphics, while PLBwire measures three-dimensional graphics performance using wireframe representation. Not included in these performance figures is GPC's benchmark for 3-D solid-graphics picture representation.

For two main reasons, these results may not agree with the workstation vendor's data, which are usually higher. First, the vendors tend to use their latest compilers, which may not be commercially available, and newer compilers tend to do better than older ones. Second, a wealth of compiler and precompiler settings has an impact on benchmark performance. Workstation Labs has found that the average mortal has neither the expertise nor the time to tweak compilers for maximum performance—especially since the best compiler settings vary for each type of benchmark.

Another factor tends to run counter to manufacturers' performance claims for a new architecture or a new generation. Consider the transition from the 486 to the Pentium. To exercise it thoroughly, the latter requires new compilers and software tuning,

and Intel bases its performance claims on such software. Yet most Pentium software is currently 486-based and thus does not fully exploit the new processor's features. It will probably take another year before the software base of the Pentium runs up to the processor's potential.

From Fig. 2, it is clear that the performance of four architectures—the Alpha, the PA, the MIPS, and the PowerPC—is very similar. The performance battle of the PA, the MIPS, and the RS/6000 over the past several years suggests that the leader at any given moment is determined more by product cycles than by anything else. As one of these vendors announces its latest chip and system, their performance leapfrogs the others; a few months later, another vendor announces a new chip with even higher performance—and so it goes.

Overall, the Alpha processor slightly outperforms the competition at the low end, thanks to higher clock rates, especially as compared with the PA and the PowerPC. Such a high clock rate is a disadvantage for future high-volume applications. In graphics performance, the Alpha lags behind the MIPS, the PA, and the PowerPC.

The Sparc architecture fell behind in the performance sweepstakes about four years ago and has not caught up. This lag is especially pronounced in high-end workstations. Sparc performs much like the Intel architecture. Sun, however, has been a leader in using multiple processors to speed things up, and this has kept the company in the game for high-end workstations. Benchmarking single processors is hard enough; measuring performance on symmetric multiprocessor systems is much harder. None of the benchmarks in Fig. 2 takes multiple processing systems into consideration. Perhaps Sparc will be able to catch up in about a year, when the UltraSparc becomes available.

AND IT COMES WITH... For all workstation market segments, certain features are standard in a basic system—for example, a minimum of cache memory (usually on the processor chip, with a larger secondary or external cache for extra performance), RAM, disk capacity, graphics resolution, I/O interfaces, and expansion slots. In addition, a variety of mass storage products, display monitors, and graphics accelerators must be available.

After serving up the standard features, the vendors can distinguish themselves by adding extras or innovations, some of which, over time, will become standard themselves. For instance, a CD-ROM drive is now an extra feature in most systems, but the use of CD ROMs to distribute software, documentation, and databases is growing so rapidly that they have already become standard in some workstations.

Expandability and ease of upgrading also matter to most workstation buyers. All standard features—memory, disk, graphics, and so on—should be expandable after the purchase of a unit. Some low-end workstations have traded limited expansion capabilities for lower manufacturing costs; for most buyers this is a bad trade-off. Expansion ought to be cost-effective, as well; there should be only a minor price penalty as compared with an original purchase. And when the user outgrows a product, upgrading to a more powerful one in the same line or moving to the next-generation successor should be as painless as possible.

Most users need technical support, too—above all in the early phase of ownership. But few data are available on the quality of technical support in the workstation industry. Maintenance and repair services are vital to most users, as well. The bigger vendors have large service networks; smaller ones must rely on third-party service firms. Needless to say, maintenance and service needs are specific to each buyer.

APPLICATION NEEDS. A user's individual requirements determine what applications run on a workstation, and this specificity would seem an obstacle to defining selection criteria for the machines. However, most key applications are scientific and engineering or technical in nature—ranging from computer-aided design and manufacturing (CAD/CAM), simulations, and software development to electronic documentation, network management, and databases. General criteria can therefore be established.

By and large, would-be workstation users attach most weight to their most important application. They would do better to look at a range of programs, including likely future ones. Generally, engineers will also use the workstation for the usual productivity applications, such as word processing, databases, spreadsheets, communications/e-mail, and presentation graphics.

Moreover, a large proportion of workstation users have hefty software and training investments to protect, so compatibility has a big bearing on workstation selection. Furthermore, most companies have been using PCs for some time and want their workstations to be capable of running the DOS/Windows software base. A few years ago this was a problem, but now there are several ways of providing such "sideways compatibility." Many leading PC software titles, including Lotus 1-2-3, Excel, WordPerfect, and Microsoft Word, are available today for popular Unix workstations.

What's more, the growing use of Windows emulation brings a large portion of the Windows software base to several workstation architectures. Emulation normally slows down program execution by a factor of five to 10. However, since workstations use RISC processors to provide better math and I/O performance than PCs offer, a typical low-end workstation running Windows emulation does so at about the same speed as a 386 DX PC running Windows running in native mode.

Buyers usually say that pricing is not the overriding concern in selecting a workstation. What they do not say is that if a model's cost exceeds a predetermined price threshold, it does not make the final selection list. Without question, many pricing factors strongly influence the final choice.

COST ISSUES. The entry price buys a minimal hardware system. Even though few users limit themselves to such a system, its tag is a good clue to the vendor's pricing strategy. At times it may even get too much attention. A strategy of publicizing artificially low entry prices that exclude necessary components may succeed at first but usually backfires. Most users dislike being treated like dummies, and the absence of a hard disk or monitor from a product highly touted as low-cost is not hard to spot.

Pricing should be consistent, without big jumps or gaps. A large variety of third-party peripherals always improves the pricing situation from the user's perspective.

The pricing of software—operating systems, user interface, network software, and applications—deserves more analysis than it gets. Software upgrades come like clockwork and will sooner or later dent the user's budget, so the software company's history and upgrade pricing strategy should be investigated. Application software for workstations is much more expensive than for PCs—even for the same program. Some of the price premium is justified, but most of it results from minimal competition in the Unix workstation software market. Because of competition from the Windows NT and Windows 4.0 software base, this price differential will drop in the next few years.

The system price, including peripherals and software, is often the pivotal factor in workstation selection criteria—after performance requirements are met. The vendor's or dealer's volume pricing goes hand-in-hand with the system pricing for large workstation orders. Some companies have the determination and expertise to include maintenance and service costs in the product selection process.

The price-performance ratio, crucial to buyers in the workstation industry, is counting for more in the PC industry as well. The processor and graphics price-performance should be weighted in terms of the intended applications. For some applications, the processor's integer and floating-point performance may also have different weights. A few volume buyers create unique benchmarks to measure their own application mix. Doing so requires plenty of know-how and resources, especially if the benchmarks must be ported to many architectures. Most buyers rely on published performance figures from workstation vendors, product reviews, or other sources.

To obtain a truly fair and accurate perspective on cost, it is necessary to compare real systems, running on workstation models, including actual configuration data and potential volume discounts. In general, the lowest prices—in the US $2000 to $4000 range—are for 486-based PCs. While these units and Pentium-based systems sell for less than RISC-based products, the gap is narrowing; some MIPS/Windows NT products,

for example, are very aggressively priced. As PowerPC products reach volume production later this year, their pricing will further narrow the gap.

While absolute prices favor X86 products, price-performance comparisons favor the RISC architectures, particularly when it comes to graphics. Graphics performance today has little to do with microprocessors, being dependent on dedicated graphics hardware and software, but high-level graphics development began on workstations and is thus further along, as offerings from Hewlett-Packard and Silicon Graphics attest. With the popularity of Windows software, graphics has come to matter more to X86 products, and in the future will reduce the gap in graphics performance and price-performance between them and RISC systems.

Processor price-performance, too, favors the RISC architectures. Although in the past the X86 lagged well behind the RISC processors in floating-point performance, it has been catching up fast with the arrival of the 486 and even more the Pentium. Still, the best RISC processors have a 50–100 percent floating-point advantage over it. The integer and general processor performance of all architectures is surprisingly similar.

Discounting is very intense for X86-based products because of the large number of vendors and wide distribution channels. Discounting for RISC-based products is lower. MIPS- and Sparc-based workstations have more discounting potential than others do, at least for now. PowerPC products will discount intensively as the number of product vendors increases.

CORPORATE ISSUES. A few corporate requirements usually have an impact on the selection of workstations. Probably the most decisive is the existing base of a particular workstation architecture. Using another architecture is usually out of the question unless it can offer worthwhile improvements in performance, cost, cost/performance, or something else.

Many companies have already selected one or more workstation architectures and maintain a list of those approved, an approach that narrows the number of choices and also provides several benefits. For one thing, the approved vendors often provide volume discounts. Moreover, an approved vendor list is generally accompanied by an internal support structure that helps new users learn the system or solve sticky technical problems. In addition, corporate experience can be tapped during the selection process.

The last factor that has an impact on product selection is availability. Shortages occur most often with popular new products and can override an earlier selection.

To summarize the advantages and disadvantages of the various workstation architectures, Fig. 3 on the following page shows a qualitative ranking of each architecture for each factor discussed: 1 is the worst score, 10 the best. This ranking is necessarily subjective, and users should create their own ranking to match their special perspectives and requirements. In a few cases, because of large variations between different vendors, the table provides a range.

For each segment, the scores of all factors have been added and then averaged at the end. The Pentium, PowerPC, and MIPS architectures get the highest scores, followed closely by Sparc, but it is certainly possible that events over the next year or two will upset these rankings.

In Fig. 3, all factors have equal weight. Obviously, users should adjust the numerical values in the weight column to match the factors most important to them. For instance, the most, next most, and least important factors may get weight values of 4, 2, and 1, respectively.

PERFORMANCE IMPROVEMENTS. Eight years or so of benchmark performance tests and data on several hundred machines provide a lot of information for trend analysis. But there are certainly exceptions to these general rules. The performance increases discussed here affect only the specific areas to which they apply. For instance, a disk cache lifts disk performance but has no impact on floating-point performance; a graphics accelerator speeds up graphics operations, but has little influence on disk performance, and so on.

Cache memory is one of the most effective ways of boosting performance at a reasonable

Architectural scorecard

	Alpha	MIPS	PA-RISC	Pentium	Power PC	Sparc
Business						
Installed base	1	4	3	5	1	6
Monthly sales	1	3	2	8	6	4
Marketing clout	2	3	3	10	8	5
Third-party support	3	3	3	9	6	5
Infrastructure support	2	2	2	9	5	4
Channel breadth	2	4	3	7	6	5
Architecture openness	2	4	3	2	6	5
Market openness	4	6	3	8	7	6
Competitive intensity	2	5	2	9	4	5
Market perception	3	4	4	10	8	6
Averages	2.2	3.8	2.8	7.7	5.7	5.1
Technical						
Performance: Central processing unit	9	9	9	7	9	7
Floating-point	9	9	9	6	9	6
Graphics	7	10	9	4	9	8
Disk	8	9	10	7	8	8
Product family breadth	5	7	5	7	6	7
Operating system and graphical user-interface availability	5	5	4	10	7	5
Software base	6	6	5	10	7	6
Averages	7.0	7.8	7.2	7.2	7.8	6.7
Cost						
Price: Entry	7	8	7	8	8	8
Peripheral	7	8	7	9	8	8
Software	5	6	5	9	8	6
System	6	7	6	9	8	7
Discounting	5	6	5	9	8	6
Processor price-performance	9	9	9	7	9	8
Graphics price-performance	8	10	9	7	10	8
Averages	6.7	7.7	6.8	8.2	8.4	7.2

1 Poor · 2 · 3 · 4 · 5 · 6 · 7 · 8 · 9 · 10 Very good

[3] Evenly weighting the factors for business, technology, and cost directs the potential purchaser to a clear choice of a Pentium- and PowerPC-based workstation. However, if performance factors are given more weight, then systems based on MIPS, PA RISC, and Alpha have an edge. Also, the adoption of an architecture for use in a non-workstation market requiring large numbers of processors tips the scales strongly.

cost. The degree of improvement depends on the size of the cache memory and the size and nature of the program. Cache memory in the microprocessor outperforms secondary cache memory, for instance.

As for floating-point processors, all workstations have them today. They are several times faster than the software emulation that some PC-based products use for floating-point arithmetic.

Disk performance can be enhanced by disk caching or by using more intelligent disk controllers. For instance, SCSI disk drives outperform their IDE counterparts. Unix operating systems generally boast better disk management software than MS-DOS or Windows do. Some workstation vendors tend to stay a jump ahead of their competitors.

A high-speed memory/graphics bus (for example, the PCI or VL bus), in addition to the I/O bus, smartens up a system's performance. This is primarily a PC issue; most workstations have been designed with such a bus.

The leap in performance from one microprocessor generation to the next is usually a doubling or more. During a microprocessor's lifetime, after all, such a doubling—or more—may be realized by upgrades of the clock rate, additional cache memory, and other refinements.

Considerably better system performance can also be obtained with the aid of compiler-related factors, most especially with compiler and precompiler settings. Normal upgrades of operating systems and compilers lend further assistance. There are also performance differences among various brands of compilers and operating systems.

Finally, emulating PC software on a RISC processor slows things down drastically as compared with what native RISC code can do. In general, the performance will slow by a factor of 10 for straight emulation. But some program functions (such as disk operations) can be performed by similar RISC code functions, which are much faster, so that overall, the emulation may be only three to five times slower than native code.

THE FUTURE. The holy grail of the RISC vendors has been the high-volume application (or rather, applications) that could zoom from sales of a few hundred thousand units to sales of a few million "overnight" (say, in a year or two). For the PowerPC, the Macintosh paved the way. The MIPS architecture may have found its chance in the Nintendo video-game market. Other high-volume opportunities may have an impact on the low-end workstation market, as well.

The key characteristic of video games is high-speed graphics processing, and there will be a move to video processing as soon as the price of that technology is right. Graphics processing is the strength of RISC workstations in general and of Silicon Graphics units in particular.

The second readily discernible high-volume market involves personal digital assistants (PDAs). Today, only a few hundred thousand are sold annually, but sales will grow to millions of units annually in just a few years. Current PDAs use low-end RISC processors—the AT&T Hobbit and ARM—but they form a potential market for the workstation RISC processors and for the X86 architecture as well.

Smart TVs, TV decoder boxes, or both are other potential high-volume applications, and the programmable devices will need lots of processing power. The nice thing about this business is that it would eventually grow to 10 million-plus a year in the United States alone. But that could take five or even 10 years to happen.

A further long-term opportunity for RISC processors is the automobile. Today, nearly all cars contain several microprocessors, but they are usually only 8-bit chips. In the future, high-end applications such as collision-avoidance systems or satellite-based navigation systems will require far superior levels of performance. In the long run, intelligent highways will raise the ante still further. These applications tend to have embedded controller characteristics, but the volumes would lend them a lot of glamour in the eyes of any RISC vendor.

TECHNOLOGY TRENDS. Nor is the growing importance of portable operating systems to be ignored. Unix showed the advantages, and now the rest of the computer market is following suit. Windows NT is likely to be successful across multiple platforms, as will IBM's Workplace family of operating systems.

The next step for portable software bases is acceptance of the Application Programming Interfaces (APIs), which has already started. A few API standards that are available for most operating systems may dominate the software market. If so, which ones? The most likely candidate is the Microsoft Windows 32-bit API. There is probably room for one or two more standards. The combined effect of portable operating systems, graphical user-interfaces, and APIs will be to ease the moving of software among hardware platforms. Hence, the underlying processor architecture will be less important in retaining customers in the future than it is today. The prospect should please Alpha, PA-RISC, MIPS, and Sparc, since they would be able to compete more on technical merits than on installed bases and sales rates.

Another interesting trend is the appearance of features, either hardware or software, that strengthen a system's ability to simulate or emulate software written for an architecture other than its own. The logical evolution is to group two or more processor architectures on a single chip, for that is technologically possible. The most likely future scenario is for a RISC chip to include part or all of the X86 architecture, which would also benefit the long-term future of the RISC architectures.

It is now clear that graphical user-interfaces (GUIs) such as Windows, Motif, and the Mac are winning the battle. Current GUIs are based on the so-called desktop metaphor, but a potential switch—to the physical world metaphor—is waiting in the wings.

The raw performance of workstations has been improving by 50–60 percent per year. This trend will persist. To put that in perspective, when a workstation in a given market segment is five years old, the equivalent new unit is eight to 10 times more powerful. The move toward 64-bit architectures will help maintain these yearly performance gains. In one or at most two processor generations, 64-bit architectures will dominate the market.

PRODUCT SPECTRUM. As a companion to this article, a listing of most of the currently available low-end workstations—including hardware and software features, performance data, and pricing information—has also been provided, based on information supplied directly by the vendors. ◆

Workstations for less than $7000

Performance ratings	Central processing unit	Operating systems	Memory	Mass storage	Monitor	Interfaces	Most significant features and options
Advanced Logic Research Inc., Irvine, Calif., 1-800-444-4ALR							
Evolution V/60, desktop, $3386, circle no. 251							
Specint92: 58.5 Specfp92: 52.3	Pentium, 60 MHz	(DOS 6.2, Windows 3.1, NT, OS/2 2.1, SCO Unix)	Cache: 256 kb RAM: 8 MB (128 MB)	Floppy: 3.5 inch Hard disk: 420 MB (1.37 GB) (CD ROM)	Color, 15-inch, 1024 x 768	Parallel, 2 serial	Price, performance, features
Evolution V/66, desktop, $3886, circle no. 252							
Specint92: 65 Specfp92: 57	Pentium, 66 MHz	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Evolution V ST/66 (PCI), desktop, $4386, circle no. 253							
Same as above	Same as above	Same as above	Same as above, except (192 MB)	Same as above	Same as above	Parallel, 2 serial, 1 SCSI, 4 PCI	Same as above
Evolution V ST/66 (VL), desktop, $4086, circle no. 254							
Same as above	Same as above	Same as above	Same as above, except (128 MB)	Same as above	Same as above	Parallel, 2 serial	Same as above
Apple Computer Inc., Cupertino, Calif., 1-800-776-2333							
Macintosh Quadra 950, desktop, $5948, circle no. 255							
N.A.	MC68040	Mac OS 7.0	RAM: 8 MB (64 MB)	Floppy: 3.5 inch Hard disk: 500 MB (1 GB) (CD ROM)	Color, 16-inch, 832 x 624	Serial RS-232/RS-422; audio; video RGB; I/O; SCSI; Ethernet 10 Base-2	Maximum power, expansion, flexibility
Macintosh Quadra 840 AV, desktop, $5198, circle no. 256							
N.A.	68040 with DSP	Mac OS 7.2	RAM: 8 MB (128 MB)	Floppy: 3.5 inch Hard disk: 230 MB (1 GB) (CD ROM)	Same as above	Serial RS-232/RS-422, audio; 2 S-video; 2 composite video; SCSI; Ethernet 10 Base-2; Nubus	Powerful, feature-rich: telecom, speech, and audio functions like stereo playback from CDs or Mac audio applications
APF, Greenville, S.C., 803-244-4416							
APF4001, desktop, $6995, circle no. 257							
N.A.	80486 DX2, 66 MHz	DOS 6.02 (Windows, Windows NT, OS/2, NeXTstep, Unix)	RAM: 4 MB (32 MB)	Floppy: 3.5 inch Hard disk: 170 MB (500 MB)	Color, 10.4-inch, 640 x 480	Parallel, 2 serial, 1 PCMCIA Type I or Type II	Future-oriented, space-saving, black case; active-matrix color TFT LCD display; meets EPA green PC standards
Atlantic Computer Products Inc., Los Alamitos, Calif., 714-952-2274							
PE5-60FT, deskside, $6995, circle no. 258							
N.A.	Pentium	DOS 6.2 (Windows 3.1, OS/2 2.1, SCO Unix/Xenix, Pick)	Cache: 256 kb (512 kb) RAM: 16 MB (128 MB)	Floppy: 3.5-inch Hard disk: 1.0 GB (4.0 GB) (CD ROM)	Color, 14-inch, 1280 x 1024	Parallel, 2 serial, 1 SCSI PCI, video PCI	Networking devices, tape backup; mouse, trackball or digi-board pointing devices
ACT E4D2-66FT, deskside, $5695, circle no. 259							
N.A.	80486DX2, 66 MHz	Same as above	Same as above	Same as above	Same as above	Parallel, 2 serial, 32-bit video, 32-bit SCSI	Same as above

NOTE: Items in parentheses are optional.

Performance ratings	Central processing unit	Operating systems	Memory	Mass storage	Monitor	Interfaces	Most significant features and options
AT&T Global Information Solutions, Dayton, Ohio, 1-800-225-5627							
System 3000 Model 3350, desktop, $3640, circle no. 260							
N.A.	80486 OX4, 100 MHz	OOS 6.2, Windows 3.1 (Windows NT, OS/2, NeXTstep, SCO Unix, NCR Unix V, USL Unix 4.2, Novell)	Cache: 128 kb RAM: 4 MB (192 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 120 MB (2 GB) (CD ROM)	Color, 17-inch, 1024 x 768	Parallel; 2 serial; 1 audio; video; SCSI NCR 53C 94; Ethernet 10 Base-T; Token Ring IBM 16/4	Four 32-bit Micro Channel slots available; 20-MB/s Micro Channel bus; Clarity I card for speedy graphics
BitWise Designs Inc., Rotterdam, N.Y., 1-800-367-5906, 518-358-9740							
466/ACP, high-end PC, portable, $6995, circle no. 261							
N.A.	80486 OX2, 66 MHz	OOS 6.2, (Windows, Windows NT, OS/2, NeXTstep, Unix)	Cache: 256 kb (1 Mb) RAM: 4 MB (256 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 245 MB (4 GB) (CO ROM)	Color, 10-inch, 640 x 480	Parallel, 2 serial RS-232, audio, SVGA video	Active-matrix display fully supports full-motion video; multimedia upgrades available; 4 expansion slots for customization
Compaq Computer Corp., Houston, Texas, 1-800-345-1518							
Deskpro 5/60M, deskside, $6800, circle no. 262							
N.A.	Pentium, 60 MHz	DOS 6.X (Windows 3.X)	Cache: 16 kb (256 kb) RAM: 8 MB (136 MB)	Floppy: 3.5 inch Hard disk: 510 MB (2.10 GB) (CO ROM)	Color, 1200 x 1240	Parallel, 2 serial, audio	Extraordinary power and capabilities, graphics combination provides user with speed and resolution
Dell Computer Corp., Austin, Texas, 1-800-289-3355							
Omni Plex 566, deskside, $4949, circle no. 263							
N.A.	Pentium, 66 MHz	OOS, Windows (Windows NT, OS/2, NeXTstep, Unix)	Cache: 256 kb RAM: 8 MB (142 MB)	Floppy: 3.5 inch Hard disk: 330 MB (2 GB) (CD ROM)	Color, 14-inch, 1024 x 768	Parallel, 2 serial, video, SCSI	PCI bus/EISA bus, SCSI adapter on PCI bus
DeskStation Technology Inc., Lenexa, Kan., 1-800-793-3375							
Tyne Series RISC PC/V4633x, deskside, $4415, circle no. 264							
Byte portable benchmarks: 3.15	MIPS R4600, 133 MHz	Windows NT (Windows 3.1)	Cache: 512 kb (2 Mb) RAM: 16 MB (256 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 240 MB (8 GB) CO ROM	Color, 17-inch, 1280 x 1024	Parallel, 2 serial, 1 SCSI bus logic	64-bit RISC processing power, open system compatibility—uses only industry-standard components, runs Windows NT, Windows 3.1, and DOS applications, 2 Vesa/4 1 SA
Tyne Series RISC PC/V 4633z, deskside, $6995, circle no. 265							
Same as above	Same as above	Same as above	Cache: (2 Mb) RAM: (32 MB) (256 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 520 MB (8 GB) CO ROM	Same as above	Same as above	Same as above
Digital Equipment Corp., Maynard, Mass., 1-800-DIGITAL							
DEC 3000 Model 300LX AXP Workstation, desktop, $5295, circle no. 266							
Specint92: 63 Specfp92: 75	Alpha 21064, 125 MHz	OEC OSF/1, Unix 1.3a or later (Open VMS, version 1.5 or later)	Cache: 256 kb RAM: 32 MB (256 MB)	Floppy: (3.5 inch, 2.8 MB) Hard disk: 535 MB (4.2 GB)	Color, 17-inch, 1280 x 1024	Serial RS-232; audio I/O; SCSI-2; Ethernet 10 Base-T; ISON; 2 Turbo channels 50 MB/s	Upgradable with CPU daughter card to 175 MHz; two Turbochannel slots provide graphic (3-0) and network (FODI) options

Workstations for less than $7000 *(continued)*

Performance ratings	Central processing unit	Operating systems	Memory	Mass storage	Monitor	Interfaces	Most significant features and options
Dolch Computer Systems, San Jose, Calif., 408-957-6575							
PAC 586-60C, portable, $6745, circle no. 267							
41 MIPS	Pentium	(DOS, Windows)	Cache: 512 kb RAM: 4 MB (64 MB)	Floppy: 3.5 inch Hard disk: 270 MB (1.8 GB)	Mono, 10.4-inch, 640 x 480	Parallel, 2 serial	5 open slots, 3 VL bus slots; TFT active–matrix display with 185-k colors
Everex Systems Inc., Fremont, Calif., 510-498-1111							
Everex Step UP-60, deskside, $4192, circle no. 268							
N.A.	Pentium	DOS 6.2, 5.0 (Windows 3.1 & NT, OS/2 2.1, SCO Unix 3.2.4, interactive)	Cache: 256 kb RAM: 16 MB (192 MB)	Floppy: 3.5 inch Hard disk: 340 MB (12 GB) (CD ROM)	Color, 15-inch, 1280 x 1024	Parallel; 2 serial RS-232; video PCI SVGA; SCSI PCI; PCI	PCI video and SCSI included for up to 132-MB/s burst transfer; RAM expandable to 192 MB, 256-kB/s burst; SRAM cache memory
Hewlett-Packard Co., Workstation Systems Group, Chelmsford, Mass., 1-800-637-7740							
HP 9000 series 700 Model 712/60, desktop, $3995, circle no. 269							
Specint92: 58.1 Specfp92: 79	PA-RISC 7100 LC	Unix HP-UX 9.03	Cache: 64 kb RAM: 16 MB (128 MB)	Floppy: (3.5 inch) Hard disk: 260 MB (14 GB) (CD ROM)	Color, 15-inch, 1024 x 768	Parallel; serial RS-232; 16-bit audio; video SCSI II; Ethernet	Excellent price/performance; built-in multimedia instructions in chip and MPower software; flat panel display option takes up one-fourth as much space as a 15-inch cathode-ray tube for those applications where space is at a premium
IBC/Integrated Business Computers, Chatsworth, Calif., 818-882-9007							
AD VESA, deskside, $1850, circle no. 270							
Specmark 89 = 17.81	80486DX2, 66 MHz	DOS 6.2, Windows 3.11 (NT 3.1, Unix SCO 3.2. 4.2)	Cache: 256 kb RAM: 4 MB (32 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 170 MB (1.08 GB) (CD ROM)	Color, 14-inch, 1024 x 768	Parallel; 2 serial; video SVGA; Ethernet	Price-performance ratings high; free technical support; national on-site service available
AD EISA, deskside, $2750, circle no. 271							
PC Labs Benchmark Rel 7.0-17 536	Same as above	Same as above	Cache: 256 kb (1 Mb) RAM: 8 MB (256 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 270 MB (4.2 GB) (CD ROM)	Same as above	Same as above	Same as above
AD PCI, deskside, $3650, circle no. 272							
N.A.	Pentium, 60 MHz	Same as above	RAM: 8 Mb	Floppy: 3.5 inch (5.25 inch) Hard disk: 240 MB (10 GB) (CD ROM)	Same as above	Parallel; 2 serial; video SVGA; SCSI; 3 PCI; Ethernet	Same as above
IBM Corp., Armonk, N.Y., 1-800-IBM-CALL							
IBM RISC System/6000 Powerstation M20, desktop, $4970, circle no. 274							
Specint92: 20.4 Specfp92: 29.1	RSC, 33 MHz	Unix, AIX/6000 3.2.5	RAM: 16 MB (64 MB)	Hard disk: 258 MB	Color, 17-inch, 1024 x 768	Parallel, 2 serial, SCSI, Ethernet	Low price; integrated SCSI/Ethernet; compact sizes
IBM RISC System/6000 Powerstation 22W, desktop, $6942, circle no. 275							
Specint92: 20.4 Specfp92:29.1	Power	Same as above	Same as above	Hard disk: 200 MB (2 GB) (CD ROM)	Color, 17-inch, 1280 x 1024	Parallel, 2 serial, SCSI, Ethernet	Low-cost, high-resolution two-dimensional graphics capability; upgradable to PowerPC microprocessor; optional three-dimensional graphics capability

Performance ratings	Central processing unit	Operating systems	Memory	Mass storage	Monitor	Interfaces	Most significant features and options
IBM Personal Computer Co., Somers, N. Y., 1-800-772-2227							
Value Point P60, desktop, $4798, circle no. 276							
N.A.	Pentium, 60 MHz	(DOS, 6.1, Windows 3.1 & NT, OS/2 2.1, NeXTstep, Unix)	Cache: 256 kb RAM: 16 MB (128 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 5.27 MB	Color, 17-inch, 1280 x 1024	Parallel, 2 serial, audio, video ATI, 2 PCI	PCI graphics; 256-kb level-2 cache; 1-MB video RAM
Microway Inc., Kingston, Mass., 508-746-7341							
B2T 66 EISA/VL–860, deskside, $6995, circle no. 277							
80486—20.6 MIPS i860—80 MIPS	80486 DX2, 66 MHz; i860, 40 MHz	OS/2 2.1 (DOS 6.2, Windows 3.1, Unix SCO, Sun-Interactive Unix V.3.4)	Cache: 256 kb RAM: 8 MB (64 MB)	Floppy: 3.5 and 5.25 inch Hard disk: 345 MB (18 GB) (CD ROM)	Color, 14-inch, 1024 x 768	Parallel, 2 serial, audio, video, SCSI	40-MHz i860 number smasher can deliver 80 MIPS; all software installed on hard drive bought through Microway; Micronics motherboard supports next-generation Pentium
MW Pentium EISA 60 M, deskside, $6595, circle no. 278							
N.A.	Pentium, 60 MHz	OS/2 2.1 (DOS 6.2, Windows 3.1, Unix SCO, SunSoft Unix V 4.0, Interactive Unix V 3.4)	Cache: 256 kb RAM: 8 MB (384 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 520 MB	Color, 14-inch, 1024 x 768	Parallel, 2 serial, audio, video WD 90C31	Can be populated with Microway's i860 products for numerically intensive applications; capable of supporting redundant array of inexpensive disks (RAID) levels 0, 1, and 5 with optional SCSI adapter; upgradable to future Intel processors
Mobius Computer Corp., Pleasanton, Calif., 1-800-MOBIUS-1, 510-460-5252							
P466icx, desktop, $3178, circle no. 279							
Specint92: 25 Specfp92:16 Xstones: 200k	80486 DX2, 66 MHz	Unixware 1.1 (Windows NT, Unix Solaris 2.1, SCO Open Desktop, Interactive Unix)	Cache: 256 kb RAM: 16 MB (128 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 245 MB (10.5 GB) (CD ROM)	Color, 15-inch, 1024 x 768	Parallel; 2 serial; SCSI; PCI; 3 Ethernet: thick, thin, twisted-pair	All systems pre-configured with Unix and fully tested; very fast graphics; 30-day, 100%-money-back guarantee with 1-year warranty and technical support
P566 ICX, desktop, $4458, circle no. 280							
Specint92: 65.2 Specfp92: 56	Pentium, 66 MHz	Same as above	Cache: 512 kb RAM: 16 MB (128 MB)	Same as above	Color, 17-inch, 1280 x 1024	Parallel; 2 serial; SCSI; 3 Ethernet: thick, thin, twisted-pair	Same as above
Mirage Series, Model IPS 10/AD, deskside, $6999, circle no. 281							
Specint92: 53 Specfp92: 63	Super-Sparc, 40 MHz	Unix Solaris 2.3 or 1.1	Cache: 36 kb (2 Mb) RAM: 16 MB (512 MB)	Floppy: 3.5 inch Hard disk: (6 GB) (CD ROM)	Color, 17-inch, 1152 x 900	Parallel; 2 serial; 16-bit audio; SCSI 2; 2 Ethernet: thin	100% Sparc compatible; pre-configured with Solaris, XII, Motif; 30-day 100%–money-back guarantee and 100% compatibility guarantee
Modgraph Inc., Woburn, Mass., 617-938-4488							
GX-2486C-66, portable, $3995, circle no. 282							
N.A.	80486 DX2, 66 MHz	(DOS 6.2, Windows 3.1, OS/2)	Cache: 128 kb (256 kb) RAM: 4 MB (32 MB)	Floppy: 3.5 and 5.25 inch Hard disk: 100 MB (2.2 GB) (CD ROM)	Color, 8.5-inch, 800 x 600	Parallel, 2 serial RS-232	Color Trinitron CRT; four expansion slots; available as rack-mountable
LC-486-66, portable, $5395, circle no. 283							
N.A.	Same as above	Same as above	Same as above	Same as above	Color, 10-inch, 640 x 480	Same as above	Color, active-matrix LCD; four expansion slots; three drive bays

Workstations for less than $7000 *(continued)*

Performance ratings	Central processing unit	Operating systems	Memory	Mass storage	Monitor	Interfaces	Most significant features and options
NEC Technologies Inc., Boxborough, Mass., 1-800-388-8888							
Image RISC station, desktop, $4999, circle no. 284							
N.A.	NEC V^R4400PC, 66/133 MHz	Windows NT 1.0	Cache: 128 kb RAM: 16 MB (128 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 540 MB (4 GB) CD ROM	Color, 14-inch, 1024 x 768	Parallel; 2 serial RS-232C; video; Fast SCSI-2; Ethernet 10 Base-T	Local bus video with graphics accelerator, 32-bit Ethernet, multispeed CD-ROM reader, and Windows NT are standard
Polywell Computers Inc., South San Francisco, 415-583-7222							
Poly 210 APX, desktop, $6990, circle no. 285							
N.A.	Alpha, 166 MHz	Windows NT 3.1 (OSF/1 Unix 2.1)	Cache: 256 kb (4 MB) RAM: 16 MB (256 MB)	Floppy: 3.5 inch (5.25 inch, 1.2 MB) Hard disk: 525 MB (24 GB) (CD ROM)	Color, 15-inch, 1280 x 1024	Parallel; 2 serial; SCSI Fast; PCI 32-bit	Alpha- based
Poly 586 VLB, desktop, $4060, circle no. 286							
N.A.	Pentium, 66 MHz	DOS 6.2, Windows 3.11 (WindowsNT 3.1, OS/2 2.1, SCO Unix 4.3.2)	Cache: 256 kb (2 MB) RAM: 16 MB (128 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 525 MB (91 GB) (CD ROM)	Same as above	Parallel; 2 serial RS-232; 7 Fast SCSI-2; Ethernet 10 Base-T	Up to 2-MB on-board cache memory; ISA/VL bus architecture; low-cost Pentium-based workstation
Poly 586-66 EP, deskside, $5950, circle no. 287							
N.A.	Same as above	Same as above	Cache: 256 kb (512 kb) RAM: 32 MB (192 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 2.2 GB CD ROM	Same as above	2 parallel; 2 serial RS-232; video PCI SVGA; EISA SCSI adapter; 3 PCI; Ethernet 10 Base-T	Both EISA and PCI bus for the Pentium; token-ring, ISDN, FDDI optional
Poly 586 PCI, desktop, $4995, circle no. 288							
N.A.	Same as above	Same as above	Same as above	Same as above	Same as above, except 15-inch	Parallel; 2 serial RS-232; video PCI SVGA; PCI SCSI adapter; 3 PCI; 2 Ethernet: BNC and 10 Base-T	PCI local-bus architecture, fast graphics accelerator; token-ring, ISDN, FDDI optional
Silicon Graphics Inc., Mountain View, Calif., 1-800-800-7441							
Indy R4000 PC, deskside, $4995, circle no. 289							
Specint92: 36.5 Specfp92: 37.4	MIPS R4000 PC	Unix, SGI IRIX 5.1	Cache: (1 MB) RAM: 16 MB (256 MB)	Hard disk: (2.0 GB) (CD ROM) (Floptical 3.5 inch, 21 MB)	Color, 15-inch, 1024 x 768	Parallel; 2 serial; 4 audio; Fast SCSI-2; Ethernet 10 Base-T or AUI; ISDN	High-bandwidth 64-bit system architecture with 267-MB/s system bus; built-in digital media from Indy Cam to independent video bus; binary compatibility with all Silicon Graphics computers
Sun Microsystems Computer Corp., Mountain View, Calif., 1-800-821-4643							
SPARCclassic, desktop, $3995, circle no. 290							
Specint92: 26.4 Specfp92: 21.0	Micro-Sparc	Solaris 1.1 & 2.3	RAM: 16 MB (96 MB)	Floppy: 3.5 inch Hard disk: 207 MB (22 GB)	Color, 15-inch, 1024 x 768	Parallel; 2 serial; 8-bit audio; Fast SCSI; Ethernet 10 Base-T	Lowest-priced color workstation; built-in networking; robust operating system

Performance ratings	Central processing unit	Operating systems	Memory	Mass storage	Monitor	Interfaces	Most significant features and options
Tangent Computer Inc., Burlingame, Calif., 1-800-800-5550, ext. 126							
Tangent PCI-P560 Model EE, desktop, $4988, circle no. 291							
N.A.	Pentium, 60 MHz	DOS 6.2, Windows 3.1/3.11, (Windows NT 3.1, DS/2 2.1, NeXTstep 3.1, Unix, SCD 3.2.4/Open Desktop 3.0)	Cache: 256 kb (1024 kb) RAM: 16 MB (128 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 525 MB (2.2 GB) (CD ROM)	Color, 17-inch, 1280 x 1024	Parallel, 2 serial, Fast SCSI-2; 3 PCI	Pentium processor with 64-bit cache and memory subsystem for zero-wait CPU performance; easy-open NoTools desktop case with 6 drive bays; buffered serial ports
Tangent VL466 Model EE, desktop, $3888, circle no. 292							
N.A.	80486 DX2, 66 MHz	Same as above	Cache: 256 kb RAM: 16 MB (64 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 540 MB (1 GB)	Same as above	Parallel, 2 serial	Diamond Viper accelerator; easy-open NoTools desktop case with 6 drive bays; large standard memory, disk, and monitor
Tatung Science and Technology Inc., Milpitas, Calif., 1-800-659-5902							
Microcompstation LX, desktop, $4725, circle no. 293							
Specint92: 26.4 Specfp92 21.0 (MIPS 59.1)	Micro-Sparc	Solaris 1.1	RAM: 16 MB (128 MB)	Floppy: 3.5 inch Hard disk: 340 MB (1 GB) (CD ROM)	Color, 15-inch, 1024 x 768 or 1152 x 900	Parallel; 2 serial; audio; SCSI; Ethernet	50 MHz/59.1 MIPS for under $5000; graphics performance; Solaris operating environment with choice of Motif or Dpen Windows
Toshiba Corp., Minato-Ku, Tokyo, Japan, (81+ 33) 457 8327							
T4700CT, portable, $5299, circle no. 294							
N.A.	80486 DX2, 50 MHz	DOS 6.0, Windows 3.1	RAM: 8 MB (24 MB)	Floppy: 3.5 inch Hard disk: 200 MB (320 MB)	Color, 9.5-inch, 640 x 480	Parallel, serial, 2 audio, video PCMCIA	TFT 9.5-inch color display; Windows Sound System 2.0 compatible; desktop docking capability (Docking Station IV)
TI950 CT, portable, $2949–$3099, circle no. 296							
N.A.	80486 DX2, 40 MHz	Same as above	Same as above	Floppy: 3.5 inch Hard disk: 120 MB (320 MB)	Color, 8.4-inch, 640 x 480	Parallel, serial, video, PCMCIA	486 DX2/40 performance; 8.4- inch TFT color display; price/performance
Unisys Corp., San Jose, Calif., 1-800-874-8647, ext. 902							
MPE 56061-340, desktop, $6095, circle no. 298							
N.A.	Pentium, 60 MHz	DOS 6.2, Windows 3.11 & NT 3.1, DS/2 2.1, Unix SCO, Unix 3.2, 4.2, Unixware 1.0	Cache: 256 kb RAM: 8 MB (128 MB)	Floppy: 3.5 inch Hard disk: 340 MB (3.4 GB) (CD RDM)	Color, 15-inch, 1024 x 768	Parallel, 2 serial, video, Fast SCSI-2	Integrated AIT video controller with 1-MB video RAM; 256-kb external write-back cache; integrated high-performance Adaptec 7770; 32-bit SCSI-II controls
Wyse Technology Inc., San Jose, Calif., 408-973-1200 or 1-800-GET-WYSE							
Forte GSV, desktop, $5000, circle no. 299							
N.A.	Pentium	DOS 6.2, Windows for Workgroups 3.11 (Windows 3.1 & NT, OS/2, SCO Unix)	Cache: 512 kb (2 MB) RAM: 16 MB (96 MB)	Floppy: 3.5 (5.25) inch Hard disk: 525 MB (1 GB) (CD ROM)	Color, 17-inch, 1280 x 1024	Parallel; 2 serial RS-232C; 2 Ethernet AMD	Upgrades from 486 to 64-bit Pentium processor with zero–insertion-force (ZIF) socket—no need for upgrade board; accelerated 32-bit VESA local bus video with 2-MB memory
Zenith Data Systems Corp., Buffalo Grove, Ill., 1-800-952-3099							
Z-400D+, desktop, $1999, circle no. 300							
N.A.	80486 DX2, 66 MHz	DOS 6.2, Windows 3.1, (OS/2 2.1)	Cache: 256 kb RAM: 4 MB (16 MB)	Floppy: 3.5 inch (5.25 inch) Hard disk: 245 MB (510 MB) (CD RDM)	Color, 14-inch, 1024 x 768	Parallel, serial, video	Price-performance; video speed (local bus video); expandability

Backing up the network

Vital as it is, backup for heterogeneous networks will remain a problem until standards are implemented

The many disasters—natural and otherwise—of the past year have made clear the need for reliable data backup and recovery systems for data networks. Such systems cannot, of course, prevent disasters, but they can keep them from turning into catastrophes. That said, setting them up is more easily said than done. The reason: the movement toward open, heterogeneous computing and communication environments.

Gone are the days of single-vendor proprietary networks. Today's corporate local- and wide-area networks are composed of a rapidly expanding patchwork of multivendor platforms, operating systems, and applications whose complexity is compounded by a mixture of data standards and formats [Fig. 1].

Backing up these heterogeneous networks is a problem that is not going to simply vanish with time. Dealing with it will require action, mainly the establishment of open standards for all aspects of networking—data backup and recovery as well as genuine data compatibility and portability.

STANDARDS VITAL. As the demand for open networking increases, developers of operating systems will be under growing pressure to conform to an open standard for tape formats and secondary storage systems. Third-party backup vendors will also need to adopt these industrywide standards, rather than continuing to lock customers into proprietary backup systems. Accepting an open standard, even for something as fundamental as a backup tape format, will help vendors support the growing movement toward heterogeneous environments. It will also benefit the computer-networking industry in general.

In this industry, standards—published or *de facto*—have never been established without a few battles. But once established, they have become the driving force for expanded sales and user benefits. This will doubtless prove to be true as network backup and restoration standards are finally established. Having these standards will resolve many of the long-standing problems of data compatibility that exist between today's major network operating systems, including the Novell NetWare and Microsoft Windows environments.

Jim Spicer Mountain Network Solutions Inc.

Novell is aware of the critical need for a universal storage tape format and consistent backup system application programming interfaces (APIs). That is why it has developed (with the assistance of a consortium of interested backup vendors) its storage management services (SMS) standard. A key trend in the NetWare environment is the increasing acceptance of SMS as an industry standard to drive and support secondary storage.

SMS also utilizes a media format standard, the system-independent data format (SIDF), which was developed by a consortium of independent third-party vendors. SIDF is a logical standard, not a physical one. It is designed to be used on any type of backup medium—not just tape. It will, therefore, apply to future backup system technologies and media. As the SIDF standard evolves in 1994, the remaining media format issues are being finalized to encourage this growth.

In the NetWare environment, SMS and SIDF compliance, as well as the issue of expandable media engines that will run in all of the NetWare environments, will be central issues for backup vendors and network managers [Fig. 2].

An emerging problem for network managers and users is that Microsoft Inc., another key player in the corporate networking industry, is not seriously considering SIDF. It has supplied, in its Windows NT operating system, a backup utility that writes in a format called Microsoft tape format (MTF). This format, which was supplied to Microsoft by a backup contractor, is a hacked version of a proprietary format developed for QIC-40 mini-cartridge applications. Thus, in its current state, MTF does not represent a logical and extensible format, developed and agreed upon by the general industry, for supporting networkable backup peripherals. Further exacerbating the situation, Microsoft itself is not applying MTF to its operating systems in any consistent fashion.

The ongoing lack of standards in the Microsoft Windows environment has been a problem for all concerned. To date, the Windows environment offers no clear direction for the industry in the areas of tape format and API standardization. At this point, decisions for secondary storage and tape backup APIs for Microsoft's Chicago, Windows 3.11, Windows NT, and Cairo operating systems are very scattered. The backup tape format supported in Windows NT (MTF) may not be supported in Chicago. There may be no consistent method of accessing the file systems for these two operating systems. As Microsoft Windows evolves to an object file system in Cairo, the company has, as yet, given no indication of what it will do for secondary storage.

Unless developers and vendors embrace a single standard for secondary storage and a consistent method of accessing the native file system data across platforms, true business data portability will remain a dream. Local area network (LAN) managers will have to choose one company's operating environment and hope that the managers at every organization with which they need to exchange and back up data have chosen the same environment.

VIRTUAL DESKTOP. Desktop systems are growing ever more powerful as applications designed to run on workstations with 32-bit graphical user-interfaces become the norm. As these versatile, but disk-hungry, platforms mount the desktop, users will find themselves increasingly needful of virtual storage capability for both backup services and secondary-storage applications such as HSM.

A common user interface for the various media engines is needed, along with engines that write a consistent, logical format such as SIDF. The industry will have to write backup and data management programs geared toward the use of virtual storage. Programs that will allow secondary storage systems to evolve into total storage systems will be critical. These programs will have to adhere to a consistent format so that data exchange may occur from any point in the storage system and from any medium.

The best way to implement virtual desktop storage would be to break the network up into domains of manageable size and to treat them separately. Implementing virtual storage for relatively small domains avoids or mitigates many of the problems that would be encountered if it were attempted on a network-wide basis.

A network-wide implementation would require a difficult, potentially expensive, and comprehensive software and hardware solution. Storage software would have to be on every node, it could never fail, and it would have to be bug-free from the outset. Some additional elements of risk in implementing

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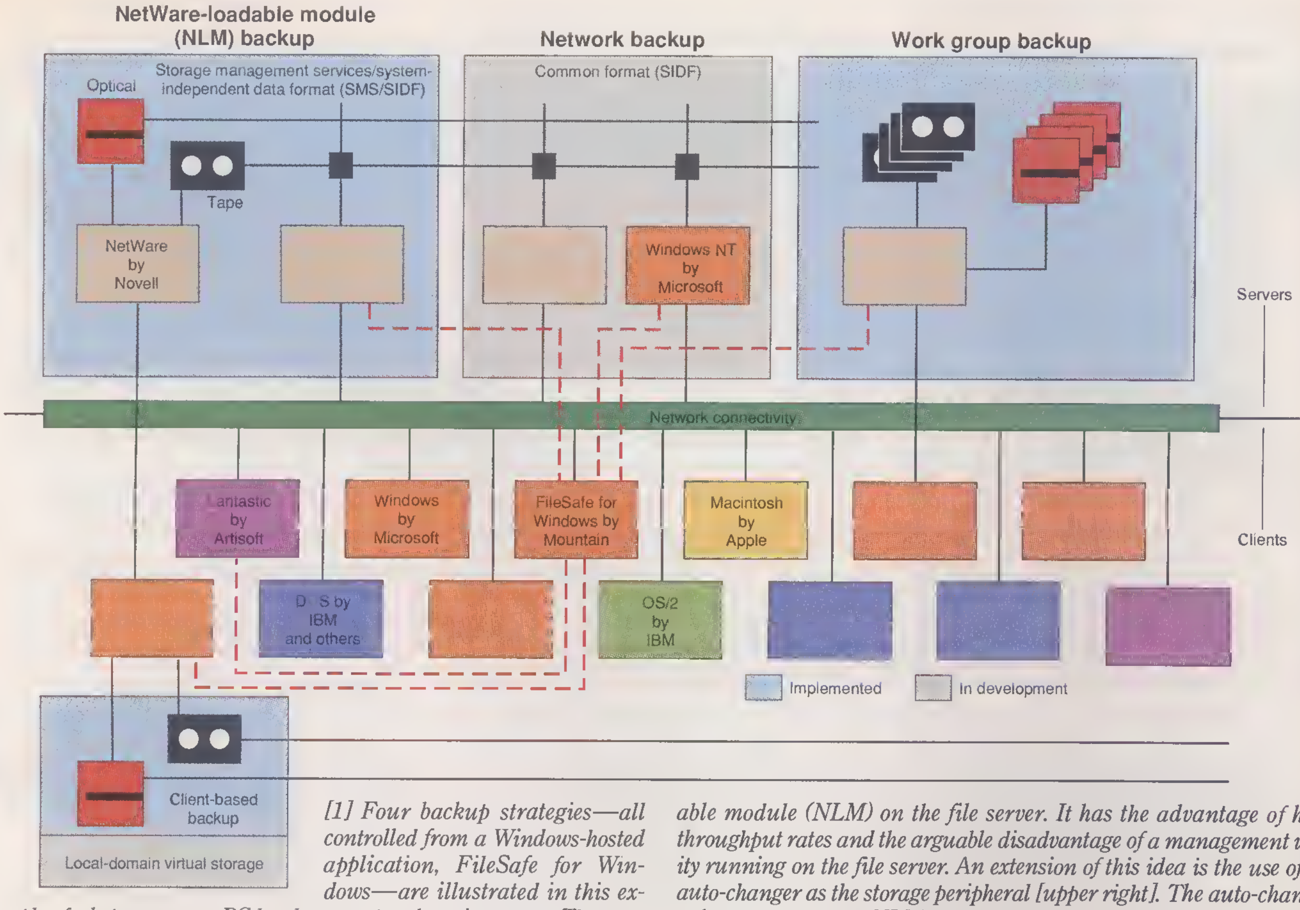
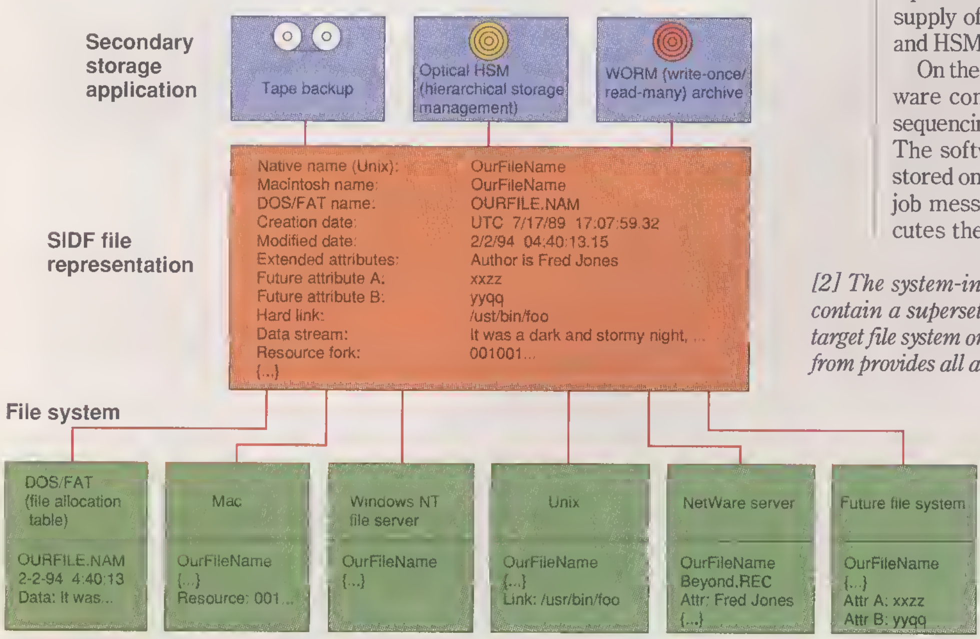


[1] Four backup strategies—all controlled from a Windows-hosted application, FileSafe for Windows—are illustrated in this example of a heterogeneous PC local-area network environment. The most traditional strategy is client-based backup [lower left] in which a tape and/or optical drive is installed at a workstation and data is pulled over the wire from remote nodes to the client workstation. The server-based strategy [upper left] runs its backup engine as a NetWare loadable module (NLM) on the file server. It has the advantage of high throughput rates and the arguable disadvantage of a management utility running on the file server. An extension of this idea is the use of an auto-changer as the storage peripheral [upper right]. The auto-changer software runs as an NLM but also pulls data from remote server and client nodes. The final strategy [middle top] is a more distributed concept. Backup is performed on all network nodes, under the control of a common client data management application, and using a common logical media format.

enterprise-wide network hierarchical storage management (HSM) have to do with the potential expense of upgrading *all* of the secondary storage peripherals to units that can tolerate duty cycles in the 70–80 percent range. (Commercial tape drives typically carry duty cycle specifications of 20 percent or lower.)

In addition to dividing the network into small domains, an auto-changer, or "stacker," is a vital element in any virtual storage system. These systems robotically handle multiple media cartridges in conjunction with one or more physically integrated tape drives, all under software control. Placed at a point of high data concentration, stackers supply off-line storage of backup, archive, and HSM services to the network.

On the desktop, the stacker's support software controls the existence, naming, and sequencing of the secondary storage media. The software also tracks the information stored on the media. When a backup task or job message is received, the stacker executes the task under full automation. It is



[2] The system-independent data format (SIDF) can contain a superset of the data set's characteristics. The target file system or associated agent that the data is read from provides all available information, which is labeled and formatted into SIDF for secondary storage. Since SIDF utilizes a tagged architecture, even future and unknown entities are handled distinctly and transparently within the free format. These are utilized if they are recognized by the receiving target file system; any unrecognized fields are simply ignored.

essential that the media management algorithms be fully adaptive so as to automatically accommodate any and all job specifications without human intervention. Of course, it should be possible to permit manual intervention if the user so desires or if it is required during maintenance operations.

After a storage task or job is completed, the catalog librarian must update both its record of the domain's file structure and its media-tracking database, alert the system operator to any logged errors, and (ideally) display messages to the operator encouraging weekly removal of the media magazine for off-site storage and rotation. A well designed auto-changer subsystem will do much of this automatically, avoiding much human error in media-handling operations.

Network data stored on removable media and made truly portable through the use of a common data format reduces the immediate need for HSM implemented at the enterprise network level. This data can be used to restore local domains of virtual storage subsystems during the anticipated development cycle of HSM for PC LANs. The much-touted vision of widespread HSM storage systems has yet to arrive—and when it does, it will be expensive to implement.

LARGE APPLICATION DEMANDS. Another driving force for both open standards and virtual desktop storage that must be addressed is the growth of data-intensive imaging and multimedia applications. Digitized audio, still images, and—most of all—full-motion color video have the potential to generate files that will dwarf those created by "ordinary" data-processing applications. As organizations increase their use of these applications, the need for increased storage capacity and a logical, industry-standard media format will become critical.

Files continue to grow in number and size, yet workstations and servers are not getting much better at moving them in and out of memory. As a result, adding lots of multimedia and imaging applications is also going to add to the number of network choke points. This will lead to greater use of data compression and off-line storage systems. The value of compression varies tremendously, of course, with the type of file affected. Graphics files can often be compressed by as much as 10:1 (and a good deal more if so-called "lossy" compression schemes are used), while executable programs can typically be compressed by no more than 2:1. Overall, if thoroughly implemented, the process might be able to reduce the amount of data to be stored by about 75 percent. Clearly, it is well worth doing. Equally clearly, it can only delay the coming data explosion, not prevent it.

As the data load on the network increases, complete nightly backup of the entire network will gradually be phased out. The size and number of the files will simply make that too expensive. Besides, because of their time requirements and data redundancies, complete network backups are not always better than differential backups. Repetitive complete backups often needlessly reproduce data that is no longer in use (such as dormant files) or data that is redundant and space-consuming (operating system and application programs).

For complete backups, tape works best because of its large capacity. The network system software and application programs can be backed up on a high-capacity SCSI tape drive and stored. Then, differential backups can be run nightly on magneto-optical disc to protect newly created files and files that have been altered. This has the advantage of providing random access to files that may have been lost or corrupted between complete backups. The cost of optical drives and media is coming down; and since they are a high-capacity durable medium, they are worth evaluating as part of a future backup strategy.

IMPORTANT FEATURES. Well-established industry-wide standards and organized virtual storage systems will equip network managers with an effective means of multi-platform backup. They will no longer have to worry about the details of individual data standards and formats. In addition, LAN managers will no longer be trapped into using proprietary backup systems. They will have the freedom to select a system based on its features and scalability.

Certain secondary backup system features will gain in importance and use for the protection of heterogeneous networks. They include volume-centric backup software (as opposed to mapped drives); automated job creation and scheduling; automated log-in access; catalog file librarians; restore-any-day capabilities; and simple disaster recovery techniques. Naturally, compliance with an industry-standard tape format will become vital.

With the acceptance of industrywide open standards, network users will be freed from bondage to a specific operating system or network operating system. They will not only have better backup and data recovery options, but also portable network data and a broader choice of applications. The standards-based consistency of the data traversing heterogeneous network environments will dazzle managers and users with its greater flexibility and reliability. Above all, they will enjoy the security of having the data on their network protected and easily rebuildable. ◆

ABOUT THE AUTHOR. Jim Spicer, vice president of engineering, has been leading Mountain Network Solutions' engineering development efforts for the past two years. Prior related experience includes developing distributed networked systems for the defense industry. Spicer is the chairman of the QIC IDC subcommittee on software applications, in which capacity he is currently working on data interchange for QIC tape drives and the establishment of an operating system standard for secondary storage. His hobbies include jazz piano and composing and sequencing electronic music.

Tape backup systems

8 mm

Capacity, GB (uncompressed/compressed)	Hardware manufacturer	SCSI termination	Software manufacturer	Operating system compatibility	Backup standard support	Other features and options
Exabyte Corp., Boulder, Colo., 1-800-EXABYTE						
EXB-10e, $15 000–$17 000 end-user, circle no. 310						
50/100	Exabyte	Ext.	Various	DOS, Windows, Mac OS, OS/2, Unix: RS/6000, HP-UX, Ultrix, Sun, Novell, PC Lan	N.A.	Reliability; user-friendliness, performance
EXB-8505, N.A., circle no. 311						
5/10	Exabyte	Int.	N.A.	DOS, Windows, Windows NT, Mac OS, OS/2, Unix: HP, DEC, Sun Micro, AIX, NLM	Win NT Tape API	Native 5 GB at 500 kB/s; compressed 10 GB at 1 MB/s; read and write compatible with all Exabyte high-performance 8-mm helical-scan tape subsystems
EXB-8205, N.A., circle no. 312						
2.5/5	Exabyte	Int.	N.A.	Same as above, plus NeXTstep,	Win NT Tape API	Native 2.5 GB at 263 kB/s; compressed 5 GB at 500 kB/s; can write and read in two formats—enhanced SCSI-2 8200C format and industry-standard 8200
Mountain Network Solutions (MTN), Scotts Valley, Calif., 408-438-6650						
FileSafe 7850-SCSI, $1395, circle no. 313						
250 MB/	MTN	Int.	MTN	DOS, Windows	SMS/SIDF	Fast file access; backup/disaster recovery software
Optima Technology Corp., Irvine, Calif., 714-476-0515						
Concorde 5000T, $2395, circle no. 314						
5/20	Optima Technology	Int.	N.A.	DOS, Windows, Windows NT, Mac OS, OS/2, NeXTstep, Unix	SMS/SIDF Win NT Tape API	500-kB/s sustained data transfer rate in native mode

DAT

Analog & Digital Peripherals Inc. (ADPI), Troy, Ohio, 1-800-758-1041						
3One For All FT 4000, $2195, circle no. 315						
4/	Exabyte	Ext.	ADPI	DOS, Windows, Mac OS, OS/2, SCO Unix, Pick, Novell, Lantastic	N.A.	Parallel and SCSI interface; One For All multiplatform support; portable and lightweight
CarNel Enterprises Inc., Placentia, Calif., 713-446-5544						
Gigastor, N.A., circle no. 316						
50/	Archive, DLI, PV, and CarNel	Ext.	None	Most Unix platforms	SMS/SIDF	Near line storage; library software optional—without it, file search and random-access archiving take typically 1 minute
Colorado Memory Systems Inc., Loveland, Colo., 1-800-845-7905						
PowerDAT 6000 Tape Backup System, $1695, circle no. 317						
/4	Hewlett-Packard	Int.	Colorado Memory Systems	DOS 2.1 and up, Windows 3.0 and up, Windows NT Native in NT, OS/2 2.0 and 2.1, SCO Unix 3.2.4 and up	ANSI/ ECMA DDS	4-GB compressed capacity (ANSI/ECMA DDS industry standard); up to 183-kB/s backup speed; includes network-compatible backup software for DOS and Windows
Conner Peripherals Inc., Costa Mesa, Calif., 1-800-4-CONNER						
TS4000 DI-SSE (Tape Stor 4000), N.A., circle no. 318						
/4	Conner Tape Products Group	N.A.	Arcada/Conner	DOS, Windows, Windows NT, Mac OS, OS/2, SCO Unix, Xenix System V, V.2.2	N.A.	Computer-grade DAT drive—electronic tape handling; 2-year warranty
4320 RW/RNT (Tape Stor 2000), $1599–$1799, circle no. 319						
16/	Same as above	N.A.	Same as above	Same as above	N.A.	Same as above
Cristie Electronics Ltd., Stonehouse, England, (44+45) 382 3611						
TS 58009, £2199, circle no. 320						
8/	WangDAT	Ext.	Cristie	DOS, Windows, OS/2, SCO Unix 4, QNX 4	Unix and Cristie QFA	Built-in SCSI and parallel ports; 367 kB/s; unlimited software license

DAT *(continued)*

Capacity, GB (uncompressed/compressed)	Hardware manufacturer	SCSI termination	Software manufacturer	Operating system compatibility	Backup standard support	Other features and options
Exabyte Corp., Boulder, Colo., 303-447-7434						
EXB-4402/EXV4402c, $1295, circle no. 321						
/8	Exabyte	Int.	N.A.	DOS 5.0, Windows 3.1 & NT 3.1, Mac OS, OS/2, SCO Unix, Interactive Unix	SMS/SIDF, Win NT Tape API	Affordable DAT drive with full DDS-2 capabilities; fast, accurate data retrieval at 233 kB/s; uses 3.5-inch form factor
FS4000DC, $1795, circle no. 322						
/4	Exabyte	Int.	FileSecure	DOS 5.0, Windows 3.1, NetWare	SMS/SIDF	Cost-effective DAT storage solution; hardware compression for data-intensive applications; rapid file retrieval
EXB-218, $15 000–$17 000, circle no. 323						
76/	Exabyte	Int.	Various	DOS, Windows, Windows NT, Mac OS, OS/2, Unix, RS/6000, HP-UX, Ultrix, Sun, Novell PC LAN	N.A.	Dual drives for redundancy and parallel processing; user-friendly design; high performance and reliability
Mountain Network Solutions (MTN), Scotts Valley, Calif., 408-438-6650						
FileSafe 1400-8, $2950, circle no. 324						
8/	MTN	Ext.	MTN	DOS, Windows	SMS/SIDF	—
FileSafe 1400, $2459, circle no. 325						
4/	MTN	Ext.	MTN	DOS, Windows	SMS/SIDF	—
Data Bank, $9995, circle no. 326						
48/	MTN	Ext.	MTN	DOS, Windows	—	—
Optima Technology Corp., Irvine, Calif., 714-476-0515						
MiniPak F8000DAT, $2295, circle no. 327						
4/16	Optima Technology	Int.	N.A.	DOS, Windows, Windows NT, Mac OS, OS/2, NeXTstep, Unix	SMS/SIDF, Win NT Tape API	510-kB/s sustained data transfer rate in native mode; multiplatform compatibility; transportable unit measures 5 by 15 by 15 cm
Palindrome Corp., Naperville, Ill., 708-505-3300						
Turbo DAT Fast 3000C, $6995, circle no. 328						
/2–6	Archive	Ext.	Palindrome	DOS, Windows, NetWare 2.X–4.X	SMS/SIDF	SMS/SIDF compliance; fully automated backup and archiving; easily upgraded to a full hierarchical storage management (HSM) system
Parallel Storage Solutions Inc., Elmsford, N.Y. 1-800-998-7839						
PDS-2 , $2995, circle no. 329						
2–4/4–8	Parallel Storage Solutions	Ext.	Parallel Storage Solutions	DOS 3.X and up; Windows 3.X; OS/2 1.3, 2.0, 2.1; NetWare 2.X, 3.X; SCO Unix 3.2.4.X; SCO Xenix 2.3.X	N.A.	Integrated hard/software turnkey solution (portable/parallel); multiplatform compatibility through parallel port connection offering typical small computer systems interface (SCSI) transfer rates
DTG-2 and -4, $3325 and $3665, circle no. 330						
2–4/4–8	Same as above	Ext.	Same as above	Same as above	N.A.	Same as above, except with 2-year warranty
PDS-4, $3295, circle no. 331						
4/8	Same as above	Ext.	Same as above	Same as above	N.A.	Same as above except with 1-year warranty
PLI Inc., Fremont, Calif., 1-800-228-8754						
PLI DAT 5 GB, $1569, circle no. 332						
2–8/	Wang DAT	Int.	Danz	Mac OS	N.A.	Danz Retrospect remote; internal active termination
PLI DAT 10 GB, $1957, circle no. 333						
4–16/	Wang DAT	Int.	Danz	Mac OS	N.A.	Same as above

DAT *(continued)*

Capacity, GB (uncom-pressed/ compressed)	Hardware manufacturer	SCSI termination	Software manufacturer	Operating system compatibility	Backup standard support	Other features and options
Procom Technology Inc., Irvine, Calif., 714-852-1000						
Procom MDAT 8000/E, $1995, circle no. 334						
4/	Sony	Ext.	Sytron	DOS, Windows, Windows NT, Mac OS, OS/2, Unix, Novell Netware	Win NT Tape API	Hardware data compression; QFA support; network support
Sony Electronics Inc., San Jose, Calif., 1-800-352-7669						
SDT-2000, -4000, and -5000 3.5-inch, DDS-2 Tape Drive, $1595, $1695, and $1995, circle no. 335						
2–4/	Sony	Int.	Depends on system inte-grator	Depends on system integrator	N.A.	3.5-inch form factor and embedded SCSI-2 controller provide compat-ibility with wide range of com-puters; flash memory for easy maintenance

DC6000

Colorado Memory Systems Inc., Loveland, Colo., 1-800-845-7905						
Power Tape 1100 Tape Backup System, $799, circle no. 336						
/1	Tandberg	Int.	Colorado Memory Systems	DOS 2.1 and up, Windows 3.0 and up, Windows NT, OS/2 2.0 and 2.1, SCO Unix 3.2.4 and up	QIC-525	1-GB compressed capacity (QIC-525 industry standard); up to 200-kB/s backup speed; network-com-patible backup software for DOS and Windows included
Power Tape 2400 Tape Backup System, $1295, circle no. 337						
/2.4	Tandberg	Int.	Colorado Memory Systems	Same as above	QIC-1000	2.4-GB compressed capacity (QIC-1000); up to 300-kB/s backup speed; same software as above
Power Tape 4000 Tape Backup System, $1695, circle no. 338						
/4	Tandberg	Int.	Colorado Memory Systems	Same as above	QIC-2 GB	4-GB compressed capacity (ANSI/ECMA DDS); up to 183-kB/s backup speed; same software as above
Cristie Electronics Ltd., Stonehouse, England, (44+45) 382 3611						
TS 42009, £1699, circle no. 339						
4/	Tandberg	Ext.	Cristie	DOS 5.X and 6.X, Windows 3.X, OS/2 2.1, SCO Unix, QNX	Unix and Cristie QFA	Built-in SCSI and parallel ports; 300 kB/s; 2-year warranty
TS 4525 Portable, £1299, circle no. 340						
1/	Tandberg	Ext.	Cristie	Same as above	Same as above	Same as above, except 200 kB/s
Parallel Storage Solutions Inc., Elmsford, N.Y., 1-800-998-7839						
PSS series, $1495–$2695 and up, circle no. 341						
0.250–5/0.525 –10	Parallel Storage Solutions	Ext.	Parallel Storage Solutions	DOS 3.X and up; Windows 3.; OS/2 1.3, 2.0, 2.1, SCO Unix 3.2.4.X; SCO Xenix 2.3.X; NetWare 2.X, 3.X	N.A.	Integrated hard-/software turnkey solution (portable/parallel); multi-platform compatibility through parallel port connection offering typical SCSI transfer rates
BTG series, $1995–$3295 and up, circle no. 342						
Same as above	Same as above	Ext.	Same as above	Same as above	N.A.	Same as above, in kit form, with extras
Tandbert Data, Westlake Village, Calif., 805-495-8384						
Panther Tape Backup, $915–$2812 , circle no. 343						
0.25–2.5/	Tandberg Data	Ext./Int.	Sytron, Cheyenne, Dantz	DOS, Windows, OS/2, Unix, NetWare	SMS/SIDF, Win NT Tape API	Very high-reliability tape drives; open architecture and industry standard software; complete QIC high performance and product line
Valitek Inc., Amherst, Mass., 413-549-2700						
PST2-1000, $1295, circle no. 344						
/1	Valitek	Ext.	Valitek	DOS, Windows, Windows NT, Mac OS, OS/2	Proprietary	Parallel port interface; can be used with any PC or MacIntosh; backup rates up to 200 kB/

DC2000

Capacity, GB (uncom-pressed/ compressed)	Hardware manufacturer	SCSI termination	Software manufacturer	Operating system compatibility	Backup standard support	Other features and options
Colorado Memory Systems Inc., Loveland, Colo., 1-800-845-7905						
Jumbo 250 Tape Backup Systems, $199, circle no. 345						
/0.25	Colorado Memory Systems	N.A.	Colorado Memory Systems	DOS 2.1 and up; Windows 3.0 and up; Windows NT; OS/2 2.0, 2.1; SCO Unix 3.2V4.X and /below; Interactive Unix 3.2V4; AT&T Unix 3.2V2; and Intel Unix	QIC-80	250-MB compressed capacity (QIC-80 industry standard); operates from PC's existing floppy controller; includes network-compatible backup software for DOS and Windows
Jumbo 500 Tape Backup System, T.B.A., circle no. 346						
/0.5	Same as above	N.A.	Same as above	Same as above	QIC-3010 MC	Same as above, except 500-MB compressed capacity
Cristie Electronics Ltd. , Stonehouse, England, (44+45) 382 3611						
Personal Tape, $599, circle no. 347						
0.25/	IOmega	N.A.	Cristie	DOS 5.0 and 6.0, Windows, OS/2 2.1	Cristie OFA	Parallel port; on-board error detection and correction; 133 kB/s
Datasure Technologies Inc., Walnut Creek, Calif., 510-935-9899						
250 Mini, $399, circle no. 348						
0.12/0.25	N.A.	N.A.	Gazelle	DOS, OS/2	QIC-80	Parallel port interface; easily fits in briefcase—measures 20 by 10 by 4 cm; uses only 400 kB of disk space
Exabyte Corp., Boulder, Colo., 1-800-Exabyte						
EXB-2501/FSIG, $895, circle no. 349						
1/2	Exabyte	Ext./Int.	N.A.	DOS, Windows, Windows NT, OS/2, File Secure 2.0	N.A.	Native capacity: 1 GB; compressed: 2 GB (software); 567 kB/s; QIC supported; SCSI interface; 3.5-inch form factor
Micro Solutions Inc., Dekalb, Ill., 815-756-3411						
Backpack Tape Drive (#141080), $489, circle no. 350						
0.12–0.25	N.A.	Ext.	Quest Development	DOS, Windows	N.A.	The first parallel port QIC-80 tape drive marketed; Windows and DOS software included at no charge; automatically recognizes and supports enhanced parallel ports
Mountain Network Solutions (MTN), Scotts Valley, Calif., 408-438-6650						
File Safe 7500 and 72000, $1695 and $1995, circle no. 351						
0.525 and 4.0/	MTN	Int.	MTN	DOS, Windows	SMS/SIDF	Fully SIDF compliant; backup/ disaster recovery; fast recovery
File Safe Side Car II, $695, circle no. 352						
0.305/	MTN	Ext.	MTN	DOS, Windows	SMS/SDIF	Same as above

TEAC

Capacity, GB (uncom-pressed/ compressed)	Hardware manufacturer	SCSI termination	Software manufacturer	Operating system compatibility	Backup standard support	Other features and options
Analog & Digital Peripherals Inc., Troy, Ohio, 1-800-758-1041						
One For All FT 6000, $1495, circle no. 353						
0.6	TEAC	Ext.	ADPI	DOS, Windows, OS/2, SCO Unix, Pick, Novell, Lantastic	N.A.	Parallel and SCSI interface; format and verify on the fly; supports multiple formats
One For All FT 1, $998, circle no. 354						
0.16	TEAC	Ext.	ADPI	Same as above, plus Mac OS	N.A.	Parallel and SCSI interface; multiplatform; portable and lightweight
Philips LMS, Colorado Springs, Colo., 1-800-777-5674, 719-593-7900						
TD 3610, $20 000, circle no. 355						
0.8/(per tape)	Philips LMS	Ext.	N.A.	DOS, Unix, AS400, RS/6000	N.A.	Fully 3490E compatible; fast and wide SCSI; air-bearing gentle tape path
TD 3620 Rapid Stacker, $23 000, circle no. 356						
0.8/(per tape)	Philips LMS	Int.	N.A.	DOS, Unix	N.A.	Same as above

rienced what reading from afar will be like, thanks to optical disc technology.

The option was, for instance, open to visitors to "Spain in America 1492–1600: What is the Legacy?," an exhibition held in 1992 at the Huntington Library, San Mateo, Calif. They could search through a 600-MB list of documents from the time of the Spanish exploration of the New World—reference works stored in an archive half a world away in Spain and accessed by satellite-computer link. After selecting an item, they could view an original artifact such as the one shown at far right. This was possible because the *Archivo General de Indias* in Seville had computer-scanned over nine million pages of historical texts and maps and stored them on more than 3000 write-once, read-mostly (WORM) optical discs.

MULTIMEDIA ON LINE. While day-to-day business uses of optical storage may not be as dramatic as viewing documents written by Christopher Columbus, they, too, can involve sharing multimedia information stored in a distant locale. For instance, while working on IBM ES/9000 mainframe assembly lines in France and Japan, manufacturing personnel are now being trained by means of multimedia programs stored at IBM Corp.'s Kingston, N.Y., facility.

Over 1 terabyte of training, product, and safety information—including full-motion videos—is available to workers from the WORM- and erasable-media library overseen by Plasmon Data Systems Inc.'s MegaStore, a jukebox for optical discs. Operators get the training programs they request using PS2 PCs (the system has more than 200) over a fiber-distributed data interface (FDDI) network running at 100 Mb/s. New operators

Richard Comerford Senior Editor

bly jobs by watching detailed videos of expert technicians at work. For their part, experienced operators use the system to brush up on seldom-performed operations, as well as to learn how to use new tools.

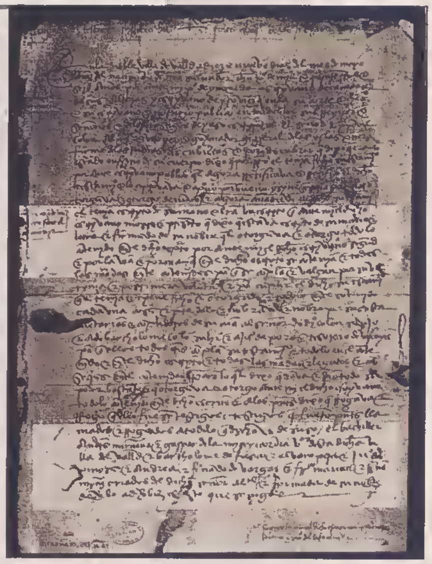
Another reason for turning to optical media is their ecological impact. Recently, the United States' Government Services Administration, working with AT&T, began using optical discs to save 187 trees a month. AT&T started delivering the government's phone bills—a whopping 1.1 million pages a month—on both write-once and erasable media.

In small companies that do not handle massive amounts of data, optical-disc technology can still be an important part of everyday operations. *Personal Daily PlanIt*, seen above and available on CD ROM from Media Vision's Publishing Group in Fremont, Calif., is a daily planner. It can boost office workers' efficiency by recording spoken notes, searching for appointments when given a voice command, and presenting inspirational video clips.

Many leading engineering-software houses are already using CD ROMs as a way of distributing large software applications. But even small companies that want to publish limited runs of CD-ROM software can now afford to do it themselves. In the last year, systems for recording CDs have appeared on the market priced at US $6000 or so. So a company need not go to a CD-ROM mastering facility and pay a $2000 fee each and every time it wants to publish a CD ROM.

MEDIUM CHOICES. As the aforementioned applications indicate, optical storage opens up new possibilities. That being the case, it is best to view the optical storage products in the following table as unique, and not just a replacement for other media. For example, optical storage will not replace hard disks:

dia is as much as two orders
enser, it takes more than
access. Floppy disks, while
come close to optical media
ess and are the right size for
ocuments of text around.
sed optical drives are faster
drives. Also, optical media
ore securely for longer peri-
edia cost less.
ording is done by changing
f a bit-storage location on a
nce between the two basic
media—in order of appear-
d erasable—is whether the
ivity can be reversed.



A letter from Columbus, recording daily events in the New World, is among the documents and maps now stored on optical discs at Spain's Archivo General de Indias.

Recording on a WORM disc (CD ROMs and CD recordable are actually WORM media) permanently alters reflectivity, either by changing the solid-state phase of the disc material or by creating a pit or bubble in it.

To write data at a bit location, a recording laser hits the spot with a high-power pulse, quickly heating the location and either pitting it or raising a bubble so that it changes phase. To read already recorded data, the laser is again beamed at the location, but at too low a power to change it. The amount of light reflected determines whether the location holds a 1 or 0.

Although both types work with WORM media, most CD-ROM drives are designed

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DC2000

Capacity, GB (uncom-pressed/compressed)	Hardwa[re] manufact[urer]					
Colorado Memory Systems In						
Jumbo 250 Tape Backup Syst						
/0.25	Colorado Memory Systems					
Jumbo 500 Tape Backup Syst						
/0.5	Same as ab					
Cristie Electronics Ltd. , Ston						
Personal Tape, $599, circle n						
0.25/	IOmega					
Datasure Technologies Inc.,						
250 Mini, $399, circle no. 34						
0.12/0.25	N.A.					space
Exabyte Corp., Boulder, Colo., 1-800-Exabyte						
EXB-2501/FSIG, $895, circle no. 349						
1/2	Exabyte	Ext./Int.	N.A.	DDS, Windows, Windows NT, DS/2, File Secure 2.0	N.A.	Native capacity: 1 GB; compressed: 2 GB (software); 567 kB/s; QIC supported; SCSI interface; 3.5-inch form factor
Micro Solutions Inc., Dekalb, Ill., 815-756-3411						
Backpack Tape Drive (#141080), $489, circle no. 350						
0.12–0.25	N.A.	Ext.	Quest Development	DDS, Windows	N.A.	The first parallel port QIC-80 tape drive marketed; Windows and DDS software included at no charge; automatically recognizes and supports enhanced parallel ports
Mountain Network Solutions (MTN), Scotts Valley, Calif., 408-438-6650						
File Safe 7500 and 72000, $1695 and $1995, circle no. 351						
0.525 and 4.0/	MTN	Int.	MTN	DDS, Windows	SMS/SIDF	Fully SIDF compliant; backup/disaster recovery; fast recovery
File Safe Side Car II, $695, circle no. 352						
0.305/	MTN	Ext.	MTN	DOS, Windows	SMS/SDIF	Same as above

TEAC

Analog & Digital Peripherals Inc., Troy, Ohio, 1-800-758-1041						
One For All FT 6000, $1495, circle no. 353						
0.6	TEAC	Ext.	ADPI	DOS, Windows, OS/2, SCO Unix, Pick, Novell, Lantastic	N.A.	Parallel and SCSI interface; format and verify on the fly; supports multiple formats
One For All FT 1, $998, circle no. 354						
0.16	TEAC	Ext.	ADPI	Same as above, plus Mac OS	N.A.	Parallel and SCSI interface; multiplatform; portable and lightweight
Philips LMS, Colorado Springs, Colo., 1-800-777-5674, 719-593-7900						
TD 3610, $20 000, circle no. 355						
0.8/(per tape)	Philips LMS	Ext.	N.A.	DDS, Unix, AS400, RS/6000	N.A.	Fully 3490E compatible; fast and wide SCSI; air-bearing gentle tape path
TD 3620 Rapid Stacker, $23 000, circle no. 356						
0.8/(per tape)	Philips LMS	Int.	N.A.	DDS, Unix	N.A.	Same as above

The multimedia drive

Because of its density, optical storage is a natural not only for multimedia, but for backing up networks and distributing tons of software

In a recent television commercial, AT&T Co. (now Corp.) tells viewers that some day they will be able to borrow a book without ever going to the library where it is kept. But some people have already experienced what reading from afar will be like, thanks to optical disc technology.

The option was, for instance, open to visitors to "Spain in America 1492–1600: What is the Legacy?," an exhibition held in 1992 at the Huntington Library, San Mateo, Calif. They could search through a 600-MB list of documents from the time of the Spanish exploration of the New World—reference works stored in an archive half a world away in Spain and accessed by satellite-computer link. After selecting an item, they could view an original artifact such as the one shown at far right. This was possible because the *Archivo General de Indias* in Seville had computer-scanned over nine million pages of historical texts and maps and stored them on more than 3000 write-once, read-mostly (WORM) optical discs.

MULTIMEDIA ON LINE. While day-to-day business uses of optical storage may not be as dramatic as viewing documents written by Christopher Columbus, they, too, can involve sharing multimedia information stored in a distant locale. For instance, while working on IBM ES/9000 mainframe assembly lines in France and Japan, manufacturing personnel are now being trained by means of multimedia programs stored at IBM Corp.'s Kingston, N.Y., facility.

Over 1 terabyte of training, product, and safety information—including full-motion videos—is available to workers from the WORM- and erasable-media library overseen by Plasmon Data Systems Inc.'s MegaStore, a jukebox for optical discs. Operators get the training programs they request using PS2 PCs (the system has more than 200) over a fiber-distributed data interface (FDDI) network running at 100 Mb/s. New operators

Richard Comerford Senior Editor

Personal Daily PlanIt *from Media Vision's Multimedia Publishing Group combines a computerized daily planner with video clips, voice recognition, and voice annotation.*

can learn how to perform complex assembly jobs by watching detailed videos of expert technicians at work. For their part, experienced operators use the system to brush up on seldom-performed operations, as well as to learn how to use new tools.

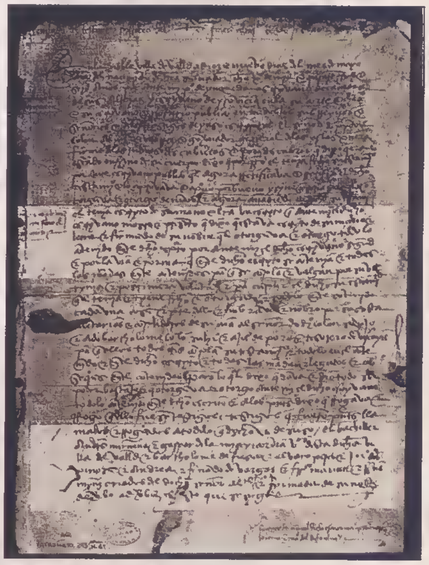
Another reason for turning to optical media is their ecological impact. Recently, the United States' Government Services Administration, working with AT&T, began using optical discs to save 187 trees a month. AT&T started delivering the government's phone bills—a whopping 1.1 million pages a month—on both write-once and erasable media.

In small companies that do not handle massive amounts of data, optical-disc technology can still be an important part of everyday operations. *Personal Daily PlanIt*, seen above and available on CD ROM from Media Vision's Publishing Group in Fremont, Calif., is a daily planner. It can boost office workers' efficiency by recording spoken notes, searching for appointments when given a voice command, and presenting inspirational video clips.

Many leading engineering-software houses are already using CD ROMs as a way of distributing large software applications. But even small companies that want to publish limited runs of CD-ROM software can now afford to do it themselves. In the last year, systems for recording CDs have appeared on the market priced at US $6000 or so. So a company need not go to a CD-ROM mastering facility and pay a $2000 fee each and every time it wants to publish a CD ROM.

MEDIUM CHOICES. As the aforementioned applications indicate, optical storage opens up new possibilities. That being the case, it is best to view the optical storage products in the following table as unique, and not just a replacement for other media. For example, optical storage will not replace hard disks: while optical media is as much as two orders of magnitude denser, it takes more than twice as long to access. Floppy disks, while they can never come close to optical media in capacity, cost less and are the right size for moving small documents of text around. Randomly accessed optical drives are faster than serial tape drives. Also, optical media will store data more securely for longer periods, but tape media cost less.

All optical recording is done by changing the reflectivity of a bit-storage location on a disc. The difference between the two basic types of optical media—in order of appearance, WORM and erasable—is whether the change in reflectivity can be reversed.



A letter from Columbus, recording daily events in the New World, is among the documents and maps now stored on optical discs at Spain's Archivo General de Indias.

Recording on a WORM disc (CD ROMs and CD recordable are actually WORM media) permanently alters reflectivity, either by changing the solid-state phase of the disc material or by creating a pit or bubble in it.

To write data at a bit location, a recording laser hits the spot with a high-power pulse, quickly heating the location and either pitting it or raising a bubble so that it changes phase. To read already recorded data, the laser is again beamed at the location, but at too low a power to change it. The amount of light reflected determines whether the location holds a 1 or 0.

Although both types work with WORM media, most CD-ROM drives are designed

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only to read data stored on a disc and are thus less expensive than WORM drives, which write as well as read. WORM drives are available for media of different diameters—300, 130, and 90 mm—so that users can select the size of discs and disc drives that are right for their storage requirements. CD-ROM drives are only for 120 mm-diameter discs, but widespread use of audio CDs makes this size the most economical of all optical media available today.

The first erasable media appeared about five years after the first WORM drives and were based on magneto-optic technology. To write data, a spot is first heated by a laser and a magnetic field applied to reverse its magnetic polarity and hence its reflectivity. The spot can then be read by the same laser used to heat it, but at a lower, non-heating power. The information is erased in the same way as it is written: by heating the spot and applying a magnetic field.

CHANGE OF PHASE. More recently, nonpermanent phase-change media have been developed. With these discs, the laser converts spots on the media surface from a dull, amorphous state into a highly reflective crystalline one. To erase data, the spot is reheated with a high-power laser pulse to change it back to its amorphous state.

The main advantage of magneto-optic media is the number of erase cycles they can withstand. They have been shown to remain functional after seven million cycles, whereas phase-change media last for only about one million. On the other hand, the read-write mechanism of a magneto-optic drive requires both a laser and magnetic coil, whereas the simpler phase-change drive needs only a laser.

Some erasable drives work not only with erasable media but with compatible WORM media, too, in which case they are called multifunction drives. These are particularly valuable in situations where there is a need to have both archival and short-term storage of data. Our survey did not turn up any erasable drives that use CD-sized discs, but there is no technical reason why such a drive could not be built.

To further expand storage capacity without resorting to extra drives, optical storage vendors provide automatic handling systems that insert and remove disks from a drive. Called jukeboxes, some of these systems can support over a terabyte of optically stored data. ◆

CD ROM

Function and type	Disk size and capacity	Number of disks	Type and source of read/write mechanism	Access time, read and/or writing speed	Other features and options
CD Technology Inc., Sunnyvale, Calif., 408-752-8500					
CD Porta-Drive T3401, $850, circle no. 400					
Read only, external	120 mm, 680 MB	1	Optic, Toshiba	200 ms, 300 kB/s	Supports Multisession Kodak Photo CD; fast, compact, lightweight and portable; guaranteed hardware- and software-compatible
CD Porta-Drive T4101, $650, circle no. 401					
Same as above	Same as above	1	Same as above	320 ms, 300 kB/s	Same as above
Disctec, Winter Park, Fla., 407-671-5500					
RoadRunner Express CD-2X, $529, circle no. 402					
Read only, external	120 mm, 630 MB	1	Optic, Mitsumi	280 ms, 350 kB/s	Parallel port interface; standard parallel port and IEEE 1284 (ECP/EPP); double-speed mechanism; portable
Extra Bit Inc., Sunnyvale, Calif., 408-737-2666					
Mitsumi Doublespeed CRMCFX0001D, $165, circle no. 403					
Read only, internal	120 mm, 680 MB	1	Optic, Mitsumi	250 ms, 300 kB/s	Supports Multisession Kodak Photo CD, ISO 9660, XA
Fidelity International Technologies Inc., Edison, N.J., 908-417-2230					
TransCD (TCD-P), $439, circle no. 404					
Read only, external	120 mm, 680 MB	1	Optic, Mitsumi	280 ms, 175 kB/s	Portable, plug-and-play, no additional slot required; parallel interface with printer pass-through, up to 4 units can be daisy-chained
TransCD (TCD2X-P), $539 circle no. 405					
Same as above	Same as above	1	Same as above	280 ms, 300 kB/s	Same as above, except double-speed version
High Technology Distributing, Van Nuys, Calif., 1-800-366-6001					
Pioneer DRM-1804x CD-ROM Minichanger, $2995, circle no. 406					
Read only, external	120 mm, 680 MB	18	Optic, Pioneer	N.A., 614 kB/s	Quad-speed data transfer; 18-disc capacity in three 6-disc cartridges; automatic disc switching in less than 5 seconds
Pioneer DRM-604x CD-ROM Minichanger, $1795, circle no. 407					
Same as above	Same as above	6	Same as above	Same as above	Same as above except single 6-disc cartridge
Pioneer DRM - 602x CD-ROM Minichanger, $1250, circle no. 408					
Same as above	Same as above	6	Same as above	N.A., 307 kB/s	Double-speed 6-disc Minichanger; 4-MB/s burst-mode transfer rate; drivers for ASPI, Future Domain, Mac, and IBM included

NOTE: Items in parentheses are optional.

Function and type	Disk size and capacity	Number of disks	Type and source of read/write mechanism	Access time, read and/or writing speed	Other features and options
Hitachi Home Electronics (America) Inc., Norcross, Ga., 201-935-8980 ext. 221					
Hitachi CDR-1900S (Hitachi Bus), $855, circle no. 409					
Read only, external	120 mm, N.A.	1	Optic, Hitachi	260 ms, 300 kB/s	Double-speed data transfer; 128-kB buffer memory; 40 000 hours mean time between failures, minimum
Hitachi CDR-1950S (SCSI), $855, circle no. 410					
Same as above	Same as above	1	Same as above	235 ms, 300 kB/s	Same as above, except has 256-kB buffer memory
Hitachi CDR-6700 (Hitachi Bus), $775, circle no. 411					
Same as above	Same as above	1	Same as above	260 ms, 300 kB/s	Double-speed transfer rate; 128-kB buffer memory; 60 000 hours mean time between failures, minimum
Hitachi CDR-6750 (SCSI), $795, circle no. 412					
Same as above	Same as above	1	Same as above	Same as above	Double-speed data transfer, except has 125-kB buffer memory
J.P.N. Corp., Fremont, Calif., 510-770-3962 ext. 102					
CDR-H93, $499, circle no. 413					
Read only, internal	120 mm, 640 MB	1	Optic, Original	320 ms, 300 kB/s	Double-speed; 256-kB cache access; mechanical tray
JVC Information Products Co. of America, Irvine, Calif., 714-261-1292					
JVC Personal Archiver, $3995, circle no. 414					
Read/write, internal, external	120 mm, 680 MB	1	Optic, N.A.	300 ms, 180-kB/s write, 300-kB/s read	Recordable CD for DOS, Mac OS, and Unix; ISO 9660 compatible
JVC Personal RomMaker, $9995, circle no. 415					
Same as above	Same as above	1	Same as above	Same as above	Recordable CD for PC; ISO 9660 compatible
Media Resources Inc., Brea, Calif., 714-256-5000					
NEC CDR-510, $357.10, circle no. 416					
Read only, internal	120 mm, 680 MB	1	Optic, NEC	195 ms, 450 kB/s	Burst-transfer rate 2.5 MB/s (async), 4.2 MB/s (sync), rotational at 600–1590 rpm (3x mode), 200–530 rpm (1x mode); SCSI-2 interface
Media Vision Inc., Fremont, Calif., 800-845-5870					
Reno Personal CD-ROM Player, $399, circle no. 417					
Read only, external	120 mm, 680 MB	1	Optic, Panasonic	180 ms, 306 kB/s	Double-speed drive runs on ac power or rechargeable NiCad batteries; includes SCSI-2 interface for IBM or Mac PCs; can play audio CDs like a Discman
Micro Solutions Inc., Dekalb, Ill., 815-756-3411					
Backpack Double Speed (#162550), $499, circle no. 418					
Read only, external	120 mm, N.A.	1	Optic, Mitsumi	250 ms, 350 kB/s	Attaches to parallel port; no interface cards to install; double-speed model for high-performance operation; automatically recognizes and supports enhanced parallel ports
NEC Technologies Inc., Wood Dale, Ill., 1-800-632-4636					
MultiSpin 4X Pro, $995, circle no. 419					
Read only, external	120 mm, 680 MB	1	Optic, NEC	180 ms, N.A.	Ergonomic design; high-speed data transfer; music sensor; front-mounted LCD and music-playback controls
MultiSpin 3Xe, $600, circle no. 420					
Same as above	Same as above	1	Same as above	195 ms, N.A.	Same as above
Orchid Technology, Fremont, Calif.; 510-683-0300					
CDS-3110, $349, circle no. 421					
Read only, internal	120 mm, 635 MB	1	Optic, Philips	Less than 350 ms, 300 kB/s	Double-speed drive; supports latest CD-ROM formats and exceeds MPC-2 compatibility; front control panels permit playing of audio CDs

CD ROM *(continued)*

Function and type	Disk size and capacity	Number of disks	Type and source of read/write mechanism	Access time, read and/or writing speed	Other features and options
Philips LMS, Colorado Springs, Colo., 719-593-7900					
CDD 521, $5249, circle no. 422					
Read/write, external	120 mm, 630 MB	1	Optic, Philips	N.A., 352- kB/s write	Host selectable single- or double-speed recording; true Multisession recording; supports all CD formats (CD-ROM, XA, Multisession, CD-I and CD Audio)
CM 206, $499, circle no. 423					
Read only, internal	120 mm, N.A.	1	N.A., Philips	350 ms, N.A.	Double-speed; motorized tray loading; MPC compatible
CM 215, $579, circle no. 424					
Same as above	Same as above	1	Same as above	Same as above	Motorized tray loading; MPC and Photo CD compatible
PMI (Pinnacle Micro Inc.), Irvine, Calif., 1-800-553-7070					
RCD-202, $3995, circle no. 425					
Read/write, external, internal	120 mm, 74 MB	1	Optic, Pinnacle	450 ms, 156 kB/s	Inexpensive; easy-to-use software; complete system
Plasmon Data Systems Inc., Milpitas, Calif.; 408-956-9400					
RF 4000 CD-R, $5995, circle no. 426					
Read/write, external	120 mm, 780 MB	1	Optic, Philips	1000 ms, 300-kB/s write	99 recording session; recordable CD
PLI (Peripheral Land Inc.), Fremont, Calif., 1-800-288-8756, 510-657-2211					
PLI CD-ROM MS, $743, circle no. 427					
Read only, external	120 mm, 650 MB	1	Optic, Toshiba	200 ms, 330 kB/s	Charismac Anubis software—can control audio through software; internal active termination
Procom Technology Inc., Irvine, Calif., 714-852-1000					
Procom MCD-DS, $665, circle no. 428					
Read only, external	120 mm, 650 MB	1	Optic, Toshiba	200 ms, 300 kB/s	Fast access time; double-speed transfer rate; SCSI interface
Ricoh Corp., Peripheral Products Division, San Jose, Calif., 408-954-5338					
RS-9200 CD Recorder, $3995, circle no. 429					
Read/write, external	120 mm, 750 MB	1	Optic, Ricoh	500 ms, 150-kB/s write	Recordable CD; Multisession (Orange Book II) compatible; dust-proof design—for reliability
Smart and Friendly, Van Nuys, Calif., 1-800-366-6001					
PCD-2200, N.A., circle no. 430					
Read only, external, internal	120 mm, 680 MB	1	Optic, Toshiba	200 ms, 330 kB/s	MPC-2, Multisession Photo CD, double-speed (330 kB/s); CD-ROM XA; 200-ms access, 256-kB buffer; SCSI-2 interface (not included)
PCD-2000, N.A., circle no. 431					
Same as above	Same as above	1	Optic, Teac CD-50	265 ms, 335 kB/s	MPC-2, photo CD, SCSI-2, Multisession, XA ready (CD-ROM XA); 335-kB/s data transfer; bundled software included
Sony Electronics Inc., San Jose, Calif., 1-800-352-7669					
CDU-7811, $529.95, circle no. 432					
Read only, external	120 mm, 680 MB	1	Optic, Sony	295 ms, 300 kB/s	MPC-2 compliant; Multisession Photo CD compatible; 256-kB buffer
CDU-561, $349.95, circle no. 433					
Read only, internal	Same as above	1	Same as above	Same as above	Internal version of above model
CDU-33A, $199.95, circle no. 434					
Same as above	Same as above	1	Same as above	320 ms, 300 kB/s	MPC-2 compliant; Multisession Photo CD compliant; 64-kB buffer
CDU-7205/N, $569.95, circle no. 435					
Read only, external	Same as above	1	Same as above	340 ms, 300 kB/s	AT interface; audio ready and auto loading; headphone jack

Function and type	Disk size and capacity	Number of disks	Type and source of read/write mechanism	Access time, read and/or writing speed	Other features and options
Toshiba America Information Systems Inc., Disk Products Division, Irvine, Calif.; 714-457-0777					
TXM-3401E, $640, circle no. 437					
Read only, external	120 mm, N.A.	1	Optic, Toshiba	200 ms, 330 kB/s	Fast access time and data transfer; high reliability—contamination-free enclosure; SCSI-2, MPC-2 compliant
XM-3401B, $510, circle no. 438					
Read only, internal	Same as above	1	Same as above	Same as above	Internal version of above
XM-4101B, $320, circle no. 439					
Read only, internal	Same as above	1	Same as above	320 ms, 300 kB/s	1-inch-high profile; high performance; MPC-2 compliant
TXM-4101L, $410, circle no. 440					
Read only, external	Same as above	1	Same as above	Same as above	High performance; MPC-2 compliant; 64-kB buffer
Yamaha Corp. of America, Systems Technology Division, San Jose, Calif., 408-437-3133					
CD Recorder CDR100, $5000, circle no. 441					
Read/write, internal	120 mm, 650 MB	1	Optic, Yamaha	500 ms, 650-kB/s write	Quadruple-speed write; half-height disk-drive form factor; Orange Book compliant
CD Expert CDE100, $5500, circle no. 442					
Read/write, external	Same as above	1	Same as above	Same as above	Quadruple-speed stand-alone system; includes 1-GB hard drive; supports CD-ROM, XA, CD-I, and CD-Digital Audio formats
Young Minds Inc., Redlands, Calif., 909-335-1350					
SimpliCD, $6495, circle no. 443					
Read/write, external	120 mm, 650 MB	1	Optic, Sony/Philips	N.A., 600-kB/s write	Multisession recording; intuitive Windows-based graphical user-interface; single-, double-, and quad-speed reading and writing
CD Studio, $18 250, circle no. 444					
Same as above	Same as above	1	Magnetic, Optic, Micropolis, Philips	15 ms, 300-kB/s write	ISO 9660/Rock Ridge compliant; networkable; ISO 9660 with translation tables
UltraCapacity CD100 XA, $13 995, circle no. 445					
Read only, external	120 mm, 650 MB	100	Optic, NSM	200 ms, N.A.	Transparent user access—no client software needed; platform independence; all discs appear as a single file system
UltraCapacity CD203x7, $34 995, circle no. 446					
Same as above	Same as above	203	Optic, Todd Enterprises	Same as above	Transparent network access—no client software is needed; all discs appear as a single file system; connects via Ethernet to TCP/IP network
UltraCapacity CD240x4, $29 995, circle no. 447					
Same as above	Same as above	240	Optic, Kubik	Same as above	Same as above

Erasable optical drives

Function and type	Disk size and capacity	Number of disks	Type and source of read/write mechanism	Access time, read and/or writing speed	Other features and options
Analog & Digital Peripherals Inc., Troy, Ohio, 513-339-2241					
RO 1300, $2995, circle no. 450					
External	130 mm, 1.3 GB	1	Magneto-optic, Sharp	38 ms, 3-MB/s parallel, 4- MB/s SCSI	Software for DOS, Windows, OS/2, Mac, SCO Unix and Novell; parallel and SCSI interface; portable and lightweight
RO 650, $2495, circle no. 451					
Same as above	130 mm, 650 MB	1	Same as above	32 ms, 3-MB/s parallel, 4- MB/s SCSI	Same as above
RO 128, $1495, circle no. 452					
Same as above	90 mm, 128 MB	1	Magneto-optic, Teac	42 ms, 3-MB/s parallel, 4- MB/s SCSI	Software for DOS, OS/2, Mac, SCO Unix, and Windows; parallel and SCSI interface; portable with handle
RO 230, $1495, circle no. 453					
Same as above	90 mm, 230 MB	1	Magneto-optic, Laser Byte	28 ms, 3-MB/s parallel, 4-MB/s SCSI	Same as above

Erasable optical drives *(continued)*

Function and type	Disk size and capacity	Number of disks	Type and source of read/write mechanism	Access time, read and/or writing speed	Other features and options
Cristie Electronics Ltd., Stonehouse, England, (44) 45 382 3611					
OD 1128, £1199, circle no. 454					
External	90 mm, 128 MB	1	Magneto-optic, MOST	38 ms, 178 kB/s	Parallel port connection; built-in data compression; includes backup software for DOS, Novell, and OS/2
Datasure Technologies Inc., Walnut Creek, Calif., 510-935-9899					
Datasure 128, $995, circle no. 455					
External	90 mm, 128 MB	1	Magneto-optic, Olympus, MOST	38 ms, N.A.	Parallel port and SCSI interfaces for unlimited online random-access storage; shock-absorption and dust-fan system; 3.5-inch form factor aids in portability; 2-year guarantee
Maxoptix Corp., San Jose, Calif., 408-954-9700					
T3-1300, $3495, circle no. 456					
External/internal	130 mm, 1.3 GB	1	Magneto-optic, Maxoptix	18.9 ms, 1.1-MB/s write, 2.2-MB/s read	Reads WORM discs; MTBF of 100 000 hours; up to 650 MB per side, formatted
MaxLyb, $6850, circle no. 457					
External	Same as above	4	Same as above	Same as above	Same as above
Optima Technology Corp., Irvine, Calif., 714-476-0515					
CTS 72, $59,995, circle no. 458					
External	130 mm, 1.3 GB	4	Magneto-optic, Sony	23 ms, 500-kB/s write	Multiplatform compatibility; 500-MB disc cache bundled free of charge; up to 72-GB storage;
CTS 26, $19 995, circle no. 459					
Same as above	Same as above	2	Same as above	Same as above	Up to 26-GB maximum storage; multiplatform compatibility; 500-MB disk cache provided free of charge
Concorde 1300MO, $3995, circle no. 460					
Same as above	Same as above	1	Same as above	Same as above	Read/write compatibility with other megabyte drives; multiplatform compatibility; lifetime guarantee on media
Plasmon Data Systems Inc., Milpitas, Calif., 408-956-9400					
RF 6800, $3995, circle no. 461					
External	130 mm, 1.3 GB	1	Magneto-optic, IBM	68 ms, 140 kB/s	Multifunction; high performance
RF 7030, $3995, circle no. 476					
Same as above	130 mm, 1.5 GB	1	Phase change, Panasonic	45 ms, 250-kB/s write	Multifunction; high speed; true write-once
RF 25 JM, $25 000, circle no. 462					
Same as above	Same as above	25	Same as above	90 ms, 220-kB/s write	Multifunction; mixed media; true write-once
RF 20 J Model 680, $11 300, circle no. 463					
Same as above	Same as above	25	Magneto-optic, IBM	68 ms, 140-kB/s write	Multifunction; mixed media
RF-1020 J Model 703-4, $225 000, circle no. 464					
Same as above	Same as above	1034	Phase change, Panasonic	45 ms, 250-kB/s write	Same as above
PLI (Peripheral Land Inc.), Fremont, Calif., 1-800-288-8756, 510-657-2211					
PLI Infinity 3.5-inch Optical LP, $1140, circle no. 465					
External	90 mm, 128 MB	1	Magneto-optic, Fujitsu	30 ms, 240-kB/s write, 768-kB/s read	Small footprint (only 5 inches wide); active termination; pre-formatted cartridge
Infinity Maxoptical 1.3 GB, $4225, circle no. 466					
Same as above	130 mm, 1.3 GB	1	Magneto-optic, Maxoptix	19 ms, 912-kB/s write, 2.2-MB/s read	WORM support; internal active termination; fastest rotation of any 5.25-inch magneto-optic drive (6800 rpm)
Infinity Optical 1.3 GB, $3599, circle no. 467					
Same as above	Same as above	1	Magneto-optic, Sony	40 ms, 700-kB/s write, 2-MB/s read	Small size (half-height device); active termination; low power consumption (15 W)

Function and type	Disk size and capacity	Number of disks	Type and source of read/write mechanism	Access time, read and/or writing speed	Other features and options
PMI (Pinnacle Micro Inc.), Irvine, Calif., 1-800-553-7070					
Alta - 20 GB, $9995, circle no. 468					
External	130 mm 1.3 GB	16	Magneto-optic, Pinnacle Micro	19 ms, 2048-kB/s write	Fast speed; data-management software for networks; cost per megabyte
Sierra 1.3 GB, $2995, circle no. 469					
External, internal	Same as above	1	Same as above	Same as above	Fast; inexpensive; reliable
Tahoe - 130, $999, circle no. 470					
Same as above	90 mm 128 MB	1	Same as above	28 ms, 768-kB/s write	Portable; fast; inexpensive
Ricoh Corp., Peripheral Products Division, San Jose, Calif., 408-954-5338					
RO-5060E, $3995, circle no. 471					
Internal	130 mm, 1.3 GB	1	Magneto-optic, Ricoh	35.4 ms, 2-MB/s write, 5.0-MB/s read	Price-performance value; dust-proof design for reliability; compatible with Ricoh RO-5031E Hyperspace drive
RO-3012E, $1995, circle no. 472					
Same as above	90 mm 128 MB	1	Same as above	<45 ms, 512-kB/s write, 4.0-MB/s read	Dust-proof design for reliability; large buffer (256-kB) for more speed
Smart and Friendly, Van Nuys, Calif., 1-800-366-6001					
Smart and Friendly 128 Magneto Optical, $1099 SRP, circle no. 473					
External	90 mm, 128 MB	1	Magneto-optic, Panasonic	≤45 ms, 640-kB/s write	Up to 256 MB of optical storage per disc (using bundled-disk IBM PC–only compression software); 640-kB/s data-transfer rate; <45-ms average seek time
Sony Electronics Inc., San Jose, Calif., 1-800-352-7669					
RMO-S550, $3995, circle no. 474					
External	130 mm, 650 MB	1	Magneto-optic, Sony	N.A., 225-kB/s write, 680-kB/s read	Quality; reliability; portability
SMD-F521, N.A., circle no. 477					
Internal	130 mm, 1.3 GB	1	Same as above	40 ms, 360-kB/s write, 1024-kB/s read	Multifunction; double capacity in half-height form factor; switchable to SCS 1 or 2
Valitek Inc., Amherst, Mass., 413-549-2700					
PST2 - MO128, $1495, circle no. 475					
External	90 mm, 128 MB	1	Magneto-optic, Panasonic	40 ms, N.A.	Parallel port interface; can be used with PC or Mac; high portability

WORM drives

Function and type	Disk size and capacity	Number of disks	Type and source of read/write mechanism	Access time, read and/or writing speed	Other features and options
Philips LMS, Colorado Springs, Colo., 719-593-7900					
LF 4502 Rapid Changer, $49 000, incl. media, circle no. 500					
Read/write, external	300 mm, 5.6 GB	10	Optic, Philips LMS	90 ms, 305-kB/s write	11.2-GB online capacity; dual-head access eliminates disk-flipping; 56-GB total capacity with 3-second access
LF 4500 Rapid Changer, $35 000, circle no. 501					
Same as above	Same as above	5	Same as above	Same as above	Same as above, except 5.6-GB online and 28-GB total capacity
Plasmon Data Systems Inc., Milpitas, Calif., 408-956-9400					
RF 10J, $12 500, circle no. 502					
Read/write, external	130 mm, 1.3 GB	11	Phase change, Panasonic	90 ms, 122-kB/s write	True write once; 50-year data life
Sony Electronics Inc., Park Ridge, N.J., 1-800-582-7669					
WDD-931, $30 000, circle no. 503					
Read/write	300 mm, 6.55 GB	1	Optic, Sony	600 ms, 900-kB/s read, 750-kB/s write	Can accommodate different configurations; lower media cost—cost per megabyte for 12-inch is a fraction of 5.25-inch cost; more real estate on each platter, fewer disk swaps and faster
WDA-330, $75 000, circle no. 504					
Same as above	Same as above	12	Same as above	Same as above	Same as above

To probe further

Benchmarks for workstation performance are set by several organizations. The most influential is Standard Performance Evaluation Corp. (SPEC), which is managed by National Computer Graphics Association (NCGA). The association's address is 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031, and the person to contact is Rodney Sanford, 703-698-9600, ext. 318. Of particular interest is a quarterly newsletter that lists the SPECmarks of newly introduced products.

NCGA also manages the Graphics Performance Characterization (GPC) Committee, founded in 1987 to define graphics benchmarks. As before, a newsletter lists the ratings of new products. The *GPC Quarterly Report* is edited by Bob Cramblitt, 919-481-4599, and now includes Xmarks as well as GPCmarks. The X Performance Committee, started last year as a part of the GPC, developed its first benchmark, Xmark93, to combine the X11perf results into a single number. The Transaction Processing Performance Council (TPC), 777 N. First St., Suite 600, San Jose, CA 95112, 408-295-8894, publishes a quarterly newsletter of TPC benchmark results.

Several consortia or associations set compliance tests and manage the evolution of assorted architectures. Sparc is the oldest, having been founded in 1989 to direct the evolution of the Sparc RISC architecture and to establish compliance definitions. Over 200 companies are members. Contact Robert Duncan, Sparc International, 535 Middlefield Rd., Suite 210, Menlo Park, CA 94025; 415-321-8692.

The Precision RISC Organization (PRO), started in 1992, supports Hewlett-Packard Co.'s Precision Architecture (PA-RISC). Currently 14 companies belong. Contact Tom Black, Precision RISC Organization, 19111 Pruneridge Ave., Cupertino, CA 95014; 408-447-7568.

The PowerOpen Association was started last year to deploy a binary-compatible application base for PowerPC-compliant platforms. Its rapidly growing membership will soon exceed 200 companies. Contact Patricia Riemitis, PowerOpen Association, 25 Burlington Mall Rd., Burlington, MA 01803; 800-457-0463.

The MIPS ABI (Application Binary Interface) group is the closest thing to a formal consortium or association for the MIPS architecture. The group defines standards for binary software compatibility (shrink-wrapped software) for all MIPS-based platforms. Contact Dave Lee, Silicon Graphics Inc., 2011 N. Shoreline Blvd., MS 9L-855, Mountain View, CA 94043; 415-390-2082.

Numerous other organizations influence or are important to the workstation industry. Among them are:

- The Association for Computing Machinery (ACM) Special Interest Group on Computer Graphics (Siggraph), 212-626-0500.
- The Corporation for Open Systems International (COSI), 703-205-2700.
- The IEEE Computer Society's Technical Committee on Operating Systems, 408-459-2666, and its Technical Committee on Distributed Processing, 602-965-2774.
- The Object Management Group (OMG), 508-820-4300.
- The Open Software Foundation (OSF), 617-621-8700.
- Osinet, 703-205-2797.
- UniForum, 408-986-8840.
- Unix International, 201-263-8400.
- X/Open Co., 415-323-7992.
- The X Industry Association, 415-962-2121.

Magazines devoted to the workstation industry may focus on just one workstation architecture or survey the workstation or graphics industry, Unix computers, and open systems. Architecture- and workstation-specific magazines include:

DEC Professional, 215-957-1500
Digital Systems Journal, 215-957-1500
HP/Apollo Workstation, 512-250-9023
HP Professional, 215-957-1500
RISC World, 512-250-9023 (for RS/6000 workstation products)
RS/Magazine, 617-739-7001 (also for RS/6000 workstation products)
Silicon Graphics World, 512-250-9023
SunExpert, 617-739-7001.

The more general magazines include *Advanced Systems/SunWorld*, 415-243-0500 (which formerly focused on Sparc systems but now covers all workstations), plus:

Computer Graphics World, 603-891-0123
IEEE Computer Graphics and Applications, 714-821-8380
Open Computing, 415-513-6800
Open Systems Today, 516-562-5000
UNIX Review, 415-358-9500
The X Journal, 212-274-0640
The X Resource, 707-829-0515.

As for books, the *PowerPC 601 RISC Microprocessor User's Manual* is available from Motorola Inc., Box 20912, Phoenix, AZ 85036. Patrick H. Corrigan's *Backing Up NetWare LANs* (M&T Books, 1992) is easy to read as well as informative. It discusses the storage management services (SMS) architecture, which is the root of the system-independent data format (SIDF) specification. Copies of that specification may be obtained from the SIDF Association, 3365 North Arlington Heights Rd., Suite J, Arlington Heights, IL 60004. (Version 1.00 of the document was approved unanimously by the association membership and published on Feb. 4, 1994.)

The Microsoft Tape Format (MTF) specification is available from Microsoft Inc., One Microsoft Way, Redmond, WA 98052.

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Catalysts for Change: Concepts and Principles for Enabling Innovation. *Rouse, William B.*, John Wiley & Sons, New York, 1993, 249 pp., $54.95.

National Innovation Systems: A Comparative Analysis. Ed. *Nelson, Richard R.*, Oxford University Press, New York, 1993, 541 pp., $49.95.

Russian-English and English-Russian Dictionary of Radar and Electronics. *Leonov, Sergey A.*, and *Barton, William F.*, Artech House, Norwood, Mass., 1993, 161 pp., $49.

Edison and the Business of Innovation. *Millard, Andre,* Johns Hopkins University Press, Baltimore, Md., 1993, 387 pp., $48.50 (hardcover), $22.95 (paperback).

Global 2000 Revisited: What Shall We Do? *Barney, Gerald O., et al.*, Millennium Institute, Arlington, Va., 1993, 120 pp., $20.

Distributed Multimedia Through Broadband Communications Services. *Minoli, Daniel,* and *Keinath, Robert,* Artech House, Norwood, Mass., 1994, 311 pp., $69.

Microsoft Publisher by Design: An Example-Packed Guide to Desktop Publishing Using Microsoft Publisher Version 2. *Simone, Luisa,* Microsoft Press, Redmond, Wash., 1994, 480 pp., $24.95.

Network Protocol Handbook. *Naugle, Matthew,* McGraw-Hill, New York, 1994, 521 pp., $49.50.

Asynchronous Transfer Mode Networks: Performance Issues. *Onvural, Raif O.*, Artech House, Norwood, Mass., 1994, 259 pp., $65.

Bill Nye, The Science Guy's Big Blast of Science. *Nye, Bill,* Addison-Wesley, New York, 1993, 176 pp., $12.95.

The Virtual Reality Primer. *Larijani, L. Casey,* McGraw-Hill, New York, 1994, 274 pp., $40 (hardcover), $24.95 (paperback).

The Grand Tour: A Traveler's Guide to the Solar System. *Miller, Ron,* and *Hartmann, William K.*, Workman Publishing, New York, 1993, 208 pp., $14.95.

Was George Washington Really the Father of Our Country?: A Clinical Geneticist Looks at World History. *Marion, Robert,* Addison-Wesley, New York, 1994, 206 pp., $21.95.

Materials Science and Engineering: An Introduction, 3rd edition. *Callister, William D., Jr.*, John Wiley & Sons, New York, 1994, 809 pp., $75.95.

High-Power Optically Activated Solid-State Switches. Eds. *Rosen, Arye,* and *Zutavern, Fred,* Artech House, Norwood, Mass., 1994, 377 pp., $88.

Electrical Engineering for All Engineers, 2nd edition. *Roadstrum, William H.*, and *Wolaver, Dan H.*, John Wiley & Sons, New York, 1994, 714 pp., $65.95.

Dynamic Vibration Absorbers: Theory and Technical Applications. *Korenev, Boris G.*, and *Leonid, M.*, John Wiley & Sons, New York, 1993, 296 pp., $89.95.

ternational Symposium on Atomic yer Epitaxy and Related Surface ocesses (ED); May 25–27; Sendai Memo- l Hall, Miyagi Prefecture, Japan; A. Kouk- Secretary, ALE-3, Faculty of Technology, kyo University of Agriculture and Tech- ogy, Koganei, Tokyo 184, Japan; (81+423) 4221, ext. 336; fax, (81+ 423) 86 3002.

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h Cement Industry Technical Con- ence (IA); May 29–June 2; Westin Hotel, Seattle, Wash.; Stephen F. Sheridan, Ash Grove Cement Co., 6720 S.W. Macadam Ave., Suite 300, Portland, OR 97219-2312; 503-293-2333.

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First International Test Synthesis Workshop (C); May 18–20; Miramar Hotel & Convention Center, Santa Barbara, Calif.; Ben Bennetts, General Chair, Synopsys, 700 E. Middlefield Rd., Mountain View, CA 94043; 415-694-4244; fax, 415-694-4249.

Microwave and Millimeter-Wave Monolithic Circuits Symposium (ED); May 23–24; San Diego Convention Center, California; Richard B. Gold, Pacific Monolithics, 245 Santa Ana Court, Sunnyvale, CA 94086-4512; 408-732-8000; fax, 408-732-3413.

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International Microwave Symposium–MTT '94 (MTT); May 24–26; San Diego Convention Center, California; Mario Maury, 8610 Helms Ave., Cucamonga, CA 91730; 714-987-4715.

International Symposium on Circuits and Systems—Iscas '94 (CAS); May 30–June 2; New Connaught Rooms, London; Robert Spence, Imperial College of Science, Department of Electrical Engineering, Exhibition Road, London SW7 2BT, Britain; (44+71) 225 8505; fax, (44+71) 581 4419.

Microwave Conference—Mikon '94–X (Poland/AES, APC, MTT); May 30–June 2; Ksiaz Castle, Warsaw, Poland; Edward Sedek, Mikon '94–Secretariat, Telecommunications Research Institute, Poligonowa 30, 00–991 Warsaw, Poland; (48+22) 1337 85; fax, (48+22) 1025 71.

Euroem '94 (AP); May 30–June 3; Palais Des Congrès, Bordeaux, France; M.V. Dhur, Euronem '94 Symposium, Centre d'Etudes de Gramat, 46500 Gramat, France; (33+65) 10 5406; fax, (33+65) 10 5433.

International Symposium on Power Semiconductor Devices and Integrated Circuits (ED); May 31–June 2; Convention Center, Davos, Switzerland; M. Ayman Shibib, AT&T Bell Laboratories, Box 13566, Reading, PA 19617-3566; 215-939-6576; fax, 215-939-6795.

International Symposium on Electron, Ion and Photon Beams (ED); May 31–June 3; Sheraton New Orleans Hotel, Louisiana; Harold Craighead, National Nanofabrication Facility, Cornell University, Knight Laboratory, Ithaca, NY 14853; 607-255-2329; fax, 607-255-8601.

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Edison and the Business of Innovation. *Mil-*

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The Virtual Reality Primer. *Larijani, L.*

York, 1994, 711 pp., $68.95.

Dynamic Vibration Absorbers: Theory and Technical Applications. *Korenev, Boris G.,* and *Leonid, M.,* John Wiley & Sons, New York, 1993, 296 pp., $89.95.

Calendar

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Columbia; L.S. Watkins, AT&T Bell Laboratories, Box 909, Princeton, NJ 08542-0900; 609-639-2468; fax, 609-639-2343.

VHDL International User's Forum (C); May 1–4; Claremont Resort & Spa, Oakland, Calif.; VHDL International, Menlo Park, Calif., 415-329-0578.

Industrial & Commercial Power Systems Technical Conference—I&CPS (IA, Orange City); May 1–5; Radisson Plaza Hotel, Irvine, Calif.; Farrokh Shokooh, Electrical Engineering Operation Tech. Inc., C.O.A., 17870 Skypark Circle, Suite #102, Irvine, CA 92714; 714-476-8117.

International Conference on Communications—ICC Supercomm '94 (COM); May 1–5; Ernest N. Morial Convention Center, New Orleans, La.; Eddie Sawaya, South Central Bell Telephone Co., 365 Canal St., Room 710, New Orleans, LA 70140; 504-528-2673; fax, 504-528-7170.

International Symposium on Electronics and the Environment (TAB); May 2–4; San Francisco; Conference Registrar, IEEE Technical Activities, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855-1331; 908-562-3878; fax, 908-562-1571.

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Instrumentation & Measurement Technology Conference—IMTC '94 (IM); May 10–12; Grand Hotel Hamamatsu, Japan; Robert Myers, Myers/Smith Inc., 3685 Motor Ave., Suite 240, Los Angeles, CA 90034–5750; 310-287-1463; fax, 310-287-1851.

Understanding Power Line Electromagnetic Fields and Corona (Montreal Chapter); May 10–13; Holiday Inn Crowne Plaza, Montreal; Nancy Mack, Conference Manager, Washington State University, Conference & Institutes, 138 Dana Hall, Pullman, WA 99164-2712; 800-942-4978 (in the United States) or 509-335-3530; fax, 509-335-9608.

International Workshop on Networked Reality in Telecommunication (COM); May 13–14; NTT Media Laboratory, Tokyo; Yoshinobu Tonomura, 1-2356, Take, Yokosuka, Kanagawa 238-03, Japan; (81+468) 59 3112; fax, (81+468) 59 2829.

OSA Optical Data Storage (IEEE/LEOS); May 16–18; Dana Point Resort, Dana Point, Calif.; Optical Society of America, 2010 Massachusetts Ave., N.W., Washington, DC 20036; 202-223-8130; fax, 202-416-6130.

International Conference on Computer Languages—ICCL '94 (C); May 16–19; University Paul Sabatier, Toulouse, France; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, DC 20036-1992; 202-371-1013; fax, 202-728-0884.

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Microwave and Millimeter-Wave Monolithic Circuits Symposium (ED); May 23–24; San Diego Convention Center, California; Richard B. Gold, Pacific Monolithics, 245 Santa Ana Court, Sunnyvale, CA 94086-4512; 408-732-8000; fax, 408-732-3413.

Intelligent Networks Workshop—IN '94 (COM); May 24–26; Penta Hotel, Heidelberg, Germany; John Visser, Bell Northern Research, Box 3511, Station C, Ottawa, ON, KiY 4H7, Canada; 613-763-7028; fax, 613-763-3585.

International Microwave Symposium–MTT '94 (MTT); May 24–26; San Diego Convention Center, California; Mario Maury, 8610 Helms Ave., Cucamonga, CA 91730; 714-987-4715.

International Symposium on Atomic Layer Epitaxy and Related Surface Processes (ED); May 25–27; Sendai Memorial Hall, Miyagi Prefecture, Japan; A. Koukitu, Secretary, ALE-3, Faculty of Technology, Tokyo University of Agriculture and Technology, Koganei, Tokyo 184, Japan; (81+423) 81 4221, ext. 336; fax, (81+ 423) 86 3002.

International Symposium on Industrial Electronics—ISIE '94 (IE); May 25–27; Catholic University of Chile, Santiago, Juan R. Pimentel, Universidad de Politecnica de Madrid, Disam, José Gutierrez Abascal 2, 28006 Madrid, Spain; (34+1) 561 6989; fax, (34+1) 564 2961.

National Telesystems Conference—NTC '94 (AES, MTT, San Diego Section); May 26–27; San Diego Convention Center, California; Robert R. Bolger, Arinc Research Corp., 4055 Hancock St., San Diego, CA 92110-5152; 619-222-7447; fax, 619-225-1750.

36th Cement Industry Technical Conference (IA); May 29–June 2; Westin Hotel, Seattle, Wash.; Stephen F. Sheridan, Ash Grove Cement Co., 6720 S.W. Macadam Ave., Suite 300, Portland, OR 97219-2312; 503-293-2333.

International Symposium on Circuits and Systems—Iscas '94 (CAS); May 30–June 2; New Connaught Rooms, London; Robert Spence, Imperial College of Science, Department of Electrical Engineering, Exhibition Road, London SW7 2BT, Britain; (44+71) 225 8505; fax, (44+71) 581 4419.

Microwave Conference—Mikon '94–X (Poland/AES, APC, MTT); May 30–June 2; Ksiaz Castle, Warsaw, Poland; Edward Sedek, Mikon '94–Secretariat, Telecommunications Research Institute, Poligonowa 30, 00–991 Warsaw, Poland; (48+22) 1337 85; fax, (48+22) 1025 71.

Euroem '94 (AP); May 30–June 3; Palais Des Congrès, Bordeaux, France; M.V. Dhur, Euronem '94 Symposium, Centre d'Etudes de Gramat, 46500 Gramat, France; (33+65) 10 5406; fax, (33+65) 10 5433.

International Symposium on Power Semiconductor Devices and Integrated Circuits (ED); May 31–June 2; Convention Center, Davos, Switzerland; M. Ayman Shibib, AT&T Bell Laboratories, Box 13566, Reading, PA 19617-3566; 215-939-6576; fax, 215-939-6795.

International Symposium on Electron, Ion and Photon Beams (ED); May 31–June 3; Sheraton New Orleans Hotel, Louisiana; Harold Craighead, National Nanofabrication Facility, Cornell University, Knight Laboratory, Ithaca, NY 14853; 607-255-2329; fax, 607-255-8601.

The Product Profiles advertising section provides a monthly, distinctive focus on both new and commercially established products and services that offer practical solutions for engineering and scientific professionals in today's fast-paced, rapidly changing high-tech environment.

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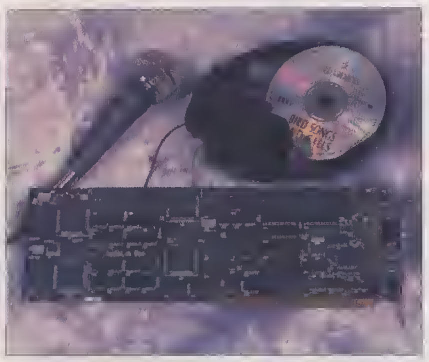
EEs' tools & toys

DSP audio board has graphics processor

Intended to provide audio experimenters with all the capability they need for doing research or developing new products, the DSP Lab One is a 16-bit plug-in board for IBM-type PCs. To avoid the bottleneck that



Capable of both analyzing and synthesizing audio signals, the DSP Lab One contains four digital signal processors along with 16-bit analog-to-digital and digital-to-analog converters.

frequently occurs in signal-processing applications when real-time displays cause enormous amounts of data to be sent over the PC bus to a video card, the board includes its own built-in graphics system. Its other main components are four TMS320C51 DSPs, a 16-bit analog-to-digital converter, and a 16-bit digital-to-analog converter.

The a-d and d-a converters are capable of handling 166 kilosamples per second—four times the rate used in making standard audio compact discs. That capability, combined with the processing power of the four DSPs (over 113 MIPS), makes the board well suited for performing filtering and other operations on high-fidelity signals.

Each DSP Lab One board is supplied with a set of tutorials, sample displays, and a monitor/loader compatible with TI's C compiler. The board sells for US $3995; an 80-MIPS version goes for $3495. *Contact: Standing Applications Laboratory, 1201 Kirkland Ave., Kirkland, WA 98033; 206-453-7855; fax, 206-453-7870; or* **circle 110.**

SOFTWARE

EE pack runs under Mathematica

Wolfram Research Inc., the creators of the well-known Mathematica symbolic mathematics package, have put together a collection of electronic notebooks and programs aimed specifically at electrical and electronics engineers. The first of a planned series of packs in the company's new Mathematica Applications Library, the Electrical Engineering Pack is organized under four main headings: circuit analysis, transmission lines, antenna design, and other tools—most of which turn out to be means for analyzing the stability of linear systems.

The pack's electronic notebooks are interactive electronic documents that are created automatically when Mathematica is used on most computer platforms. They combine live formulas, data, computations, graphics, and text to form an electronic textbook with examples that users may read, modify, and execute as their individual needs dictate.

The Electrical Engineering Pack is priced at $195. Versions are available for Macintosh, Microsoft Windows, and the X Window System. Wolfram points out that Mathematica version 2.2 is required to make full use of the materials in the pack. *Contact: Wolfram Research Inc., 100 Trade Center Dr., Champaign, IL 61820-7237; 217-398-0700; toll-free, 800-441-MATH; in Europe, (44+993) 883 400; fax, 217-398-0747; or* **circle 111.**

Program allows distributed computing

Traditionally, the Unix MAKE command is used as a mechanism for controlling the source-code compilation processes. A parallel version of the command can not only speed compilation, it can also be embedded in an application and thereby bring the power of distributed and scalable computing to the application.

At least that is the claim of Tarek Parallel Systems, creators of a parallel MAKE called Pmake. Their product, they say, gives a brand new life to the Unix makefile. (Makefile is the default name of the target of the MAKE command.) Given a suitable application, such as modular electronic design automation applications (synthesis, layout verification, partitioning, multiple gate array routing, and simulation), the makefile can be used to describe the dependency graph among the tasks needed to be executed. Pmake can then be used to execute the tasks described in the makefile on any number of workstations that the application specifies.

The makefile is generated automatically by the application after the dependency graph is carried out. Then, the application simply uses a Unix system call to execute Pmake. The tasks specified in the makefile are executed by several workstations in parallel.

Since the application can specify any number of workstations to execute the same makefile, distributed and scalable computing is made possible through the combination of Pmake and the makefile. For other network makes, this is not easily achievable since they require daemon setup before run. In contrast, Pmake requires no daemon at all. Users can just install the executable code and play it. The parallel version is thus suitable for embedding into an application to which it gives the power of distributed and scalable computing.

Pmake runs on all major Unix workstations, multiprocessors, and clusters, such as Sun, HP, IBM, and SGI workstations. IBM PC running Solaris is also supported. Pmake is compatible with Unix and GNU MAKEs. There is no need to modify user's makefiles.

Pmake is available for immediate delivery. The introductory price is $1500 per copy. Qualified readers may receive free evaluation copies. *Contact: Tarek Parallel Systems, Box 390098, Milpitas, CA 95036; 408-942-1289; e-mail, info@tarek.com; or* **circle 112.**

COMPONENTS

Radiation-effects database

Designers of avionics gear, satellites, spacecraft, and other equipment intended to operate in space or at the upper reaches of the atmosphere must be concerned with the effects of ionizing radiation on the components they build into their systems. But performing the necessary tests on those components—a difficult and expensive task—may not be necessary since many components have already been tested by competent laboratories around the world. The question is how to access the test data.

The answer is through a radiation-effects database, called Radata, which is maintained by the Radiation Effects and Testing Group at the Jet Propulsion Laboratory (JPL) in Pasadena, Calif. The database contains detailed single-event effect (SEE) and total-ionizing dose (TID) test data on over a thousand components tested by JPL and other laboratories. In addition, it lists more than 3000 components for which the Defense Nuclear Agency's Electronics Radiation Response Information Center (Erric) has test data. Thus, according to Keyvan Eslami, who administers the database, even for components on which Radata does not have complete information, it can help users quickly learn whether such data exists and where to get it.

Components covered by Radata include discrete and integrated semiconductor devices such as memory chips, microprocessors and controllers, analog-to-digital and

digital-to-analog converters, application-specific ICs, and power transistors.

The menu-driven database may be accessed by modem or through the Internet free of charge. It permits users to view, search, and download data. The modem access number is 818-393-1725. Modem line parameters are 8 data bits, 1 stop bit, and no parity at any speed up to 14.4 kb/s.

Via the Internet, the FTP address is radata.jpl.nasa.gov (137.79.11.2); the userid is "radata"; and the password is "guest." *Contact: Keyvan Eslami, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., M/S 303-220, Pasadena, CA 91109-8099; 818-354-1715; fax, 818-393-4559; e-mail, keyvan_eslami@jpl.nasa.gov; or* **circle 113.**

More on-line data

Back in the days when high-speed logic ran at 1 MHz and "party" was a noun, catalog information on electronic components was distributed on microfilm—reels of it. Users consulted an index to see which reels had the data they wanted, loaded those reels into a microfilm reader, and searched for the components they needed, scribbling notes about promising candidates for follow-up action.

The system worked reasonably well, but it was time consuming, and the data was never quite up-to-date. After all, it is not practical to replace microfilm libraries more than a few times a year. Such a system would clearly be inadequate for today's frenetic, short-time-to-market industry mentality.

What is needed today is a real-time component information source that can be easily reached from an engineer's desktop. That information source should have sophisticated search capabilities, should be continually updated, and should obviate the need for copying technical data or manufacturer's phone numbers onto scraps of paper. Such an information source is EnGenius from Info Enterprises Inc.

EnGenius is an on-line service that contains digitized product specifications, application notes, errata, work-arounds, and other information about components ranging from connectors to microprocessors to memories. Engineers access it using 9600- or 14.4-kb/s modems or via a wide-area network. With EnGenius, users may search for parts not only hierarchically (by product category) or by part number (with wild cards), but also parametrically—for example, by speed, pin count, or power consumption. Users can view, search, print, and download information into their workstations.

Information on the service is updated as often as changes occur, making it more accurate than paper or CD-ROM product documentation.

EnGenius is available now for users with Sun Unix workstations; PC users should be able to access it by the end of this month (April). Also expected soon are multimedia features (audio, video with text and graphics); group annotation capability, which will allow engineering groups to annotate documents and route them among users; and messaging, which will enable users to correspond with manufacturers.

EnGenius will cost a typical user about $49 per month. Volume pricing is available for organizations with more than 20 users per month. *Contact: Info Enterprises, 426 N. 44th St., Suite 250, Phoenix, AZ 85008-6595; 602-267-4636; toll-free, 800-851-7536; fax, 602-267-4455; or* **circle 114.**

INSTRUMENTATION

Hand-held RF signal strength meter

As interest in wireless communications systems continues to grow, system developers and installers frequently find themselves doing walk-around propagation studies using spectrum analyzers as their principal measuring tools. But at more than $20 000 and 20 kg, these general-purpose instruments are hardly ideal for the job.

A much better match is the Champ from

Tools & toys

Berkeley Varitronics. Priced at just $1995 and weighing in at a mere 1.5 kg, the handheld meter is much more convenient for such jobs as finding RF "shadows" in indoor wireless systems. It is equally suitable for drive-around studies in which, for example, cable companies look for RF leakage from their equipment.

Basically, the Champ mimics the behavior of a spectrum analyzer in its quasi-peak mode and over a limited bandwidth. Specifically, it spans the ISM (industrial, scientific, and medical) band from 900 to 932 MHz where it has a sensitivity of −120 dBm (with an 10-kHz IF bandwidth). The unit is also offered in a version that covers the cellular radio band (850–890 MHz), and can be designed to cover any 40-MHz portion of the 1.8–2.4-GHz PCS band.

Two options make the Champ particularly neat for drive-around measurements. A Global Positioning System (GPS) add-on logs the latitude and longitude at which each measurement is made, and a nonvolatile PCMCIA (Personal Computer Memory Card International Association) memory card makes a convenient means for transferring the measured data from field to office. The two options each add about a thousand dollars to the instrument's price. *Contact: Berkeley Varitronics Systems Inc., 255 Forrest St., Metuchen, NJ 08840; 908-548-3737; fax, 908-548-3404; or* **circle 116.**

GENERAL INTEREST

Weather watching

If this past year with its floods and storms has stimulated you to pay more attention to the weather, the latest catalog of weather-monitoring equipment from Davis Instruments may be of more than passing interest. The 14-page booklet gives details on the company's complete line of weather stations, from the $150 Perception II indoor climate monitor to the top-of-the-line Weather Monitor II, priced at $395.

Among the dozen-odd parameters that the latter displays are indoor and outdoor temperature, wind speed, wind direction, and wind chill factor. It also shows barometric pressure, barometric trend, indoor humidity (outdoor humidity is an extra-cost option), date, time, and minima, maxima and alarms for most measured parameters.

The best deal in the catalog is probably the Weather Wizard III [photo], which can measure most of what the Weather Monitor II measures except for humidity and barometric pressure. It is priced at $195.

The large liquid-crystal display in the Weather Wizard III weather monitor features a compass rose for indicating wind direction.

Both the Weather Monitor II and the Weather Wizard III can be fitted with an optional rain gage. Another option is the Weatherlink, a compact unit that stores readings for later downloading into a computer for analysis and graphing. *Contact: Davis Instruments, 3465 Diablo Ave., Hayward, CA 94545; 510-732-9229; fax, 510-732-9188; or* **circle 115.**

COORDINATOR: Michael J. Riezenman
CONSULTANT: Paul A.T. Wolfgang, Boeing Defense & Space Group

CLASSIFIED EMPLOYMENT OPPORTUNITIES

The following listings of interest to IEEE members have been placed by educational, goverment, and industrial organizations as well as by individuals seeking positions. To respond, apply in writing to the address given or to the box number listed in care of *Spectrum* Magazine, Classified Employment Opportunities Department, 345 E. 47th St., New York, N.Y. 10017.

ADVERTISING RATES

Positions open—$40.00 per line, not agency-commissionable

Positions wanted—$40.00 per line, a 50% discount for IEEE members who supply their membership numbers with advertising copy.

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IEEE encourages employers to offer salaries that are competitive, but occasionally a saslary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

Academic positions open

Texas A&M University. The Electrical Engineering Department expects to have several openings for tenure track faculty at all ranks. Applicants must have a Ph.D degree or completion of all requirements by date of hire. For senior positions, applicants should have a proven record of scholarly contributions, and for junior positions, demonstrated potential for quality research and teaching is necessary. The salary is competitive and commensurate with qualifications and experience. Applicants are sought in the areas of computer engineering, microelectronics, power electronics and signal processing. Applicants should send a complete resume, including names and addresses of three references to Dr. A. D. Patton, Department Head, Electrical Engineering Department, Texas A&M University, College Station, TX 77843-3128. Texas A&M University is an equal opportunity/affirmative action employer and actively seeks the candidacy of women and minorities.

The Department of Electrical Engineering at The University of Maryland Baltimore County (UMBC) anticipates two regular full-time tenure-track faculty openings at the Assistant Professor Level. The department currently offers the M.S. and Ph.D. degree and emphasizes research in photonics, micro-electronics, signal processing, and communications. The successful candidates for these positions will be expected to participate in ongoing well funded research in the area of wavelength division multiplexed optical communication systems. This effort includes significant collaboration with local government and industrial research laboratories and the facilities available for this research include MBE, MOCVD, CAIBE, and several semiconductor processing clean rooms. One position will be reserved for the area of micro-electronics as it relates to opto-electronic device processing and packaging including lasers, detectors, modulators, amplifiers, and novel devices. The second position is reserved for research performed in the area of optical communication networks. The faculty member in the optical network area is expected to interact with the device team to help realize advanced WDM systems. Each faculty member is expected to teach at the graduate and undergraduate level, establish an active research program, and attract significant external funding. Please send a current c.v. and the names of three references to Professor Yung-Jui Chen, Department of Electrical Engineering, UMBC, Baltimore, MD 21228. Applications will be accepted until suitable candidates are found. The University of Maryland Baltimore County is an AA/EEO Employer.

Massachusetts Institute of Technology, Department of Mechanical Engineering: Assistant/Associate/Full Professor Appointments for Academic Year 1994-1995. Design (theory, methodology, optimization, CAD/CAM, AI techniques, design for manufacturing). Thermofluid Sciences (e.g., fundamentals of molecular and interfacial phenomena, multiscale transport processes in simple and complex fluids, and advanced diagnostics). Systems and Transportation (e.g., systems, information and transportation, broadly interpreted to include highway, rail and other transportation systems and/or any other large-scale systems involving primarily mechanical engineering disciplines). Appointees will be selected on the basis of intellectual strength and professional promise or accomplishments. They will be expected to teach and develop undergraduate and graduate subjects, to supervise graduate student research, and to establish independent sponsored research programs. Industrial experience is desirable. Doctorate in Mechanical Engineering or related field required. Applications including a resume (include citizenship and/or visa status), publications list, references and a 1-2 page statement of current and future research interests and goals should be submitted to Faculty Search Head (please specify position), Department of Mechanical Engineering, Massachusetts Institute of Technology, Room 3-173, Cambridge, MA 02139-4307. Resumes received after April 30, 1994 may not receive full consideration. An Equal Opportunity/Affirmative Action Employer.

Director, The Center for Advanced Computer Studies. The University of Southwestern Louisiana. Nominations and applications are sought for the position of Director of The Center for Advanced Computer Studies (the Center). The financial package includes a competitive salary, an administrative stipend and a discretionary fund. The candidate may also be considered for appointment to an endowed research professorship, depending on qualifications. About The Center: The Center is primarily a research unit, with MS and PhD degree programs in computer science and computer engineering. About 200 students are enrolled in the graduate programs, of which about 100 are pursuing a PhD degree. Related programs include the CSAB accredited undergraduate program administered by the Department of Computer Science, with an enrollment of 350 students, and the ABET accredited undergraduate program in the Department of Electrical and Computer Engineering, with an enrollment of 370. The Center has currently about 20 research faculty members. A typical teaching load is one graduate course per semester and a continuing research seminar. External grants/contracts (over three million dollars in 1992-93) support research in a variety of areas. The Center has state-of-the-art research and instructional computing facilities, consisting of several networks of Sun workstations that operate under a UNIX environment. In addition, the Center has dedicated research laboratories in Artificial Intelligence, Computer Vision & Pattern Recognition, Intelligent Robotic Systems, Software Engineering, and Very Large Scale Integration. Lafayette is situated in Acadiana, the home of the world renowned Cajun cuisine. It has a population of 94,000 and is approximately 120 miles west of New Orleans. Qualifications for the Director: The candidate must have a PhD in computer science/engineering and demonstrated abilities in academic and administrative leadership. He/She must have national visibility through accomplishments in research, contract and grant funding, professional activities, etc. The candidate must be able to enhance and promote collaboration with government agencies and industrial corporations. The search committee will begin reviewing applications on April 1, 1994 and continue until the position is filled. Applications/nominations containing statements of academic, professional and administrative credentials, a detailed resume and names of five references are to be mailed to: Dr. Vijay V. Raghavan, Professor, Chairman, Search Committee for the Director, The Center for Advanced Computer Studies, The University of Southwestern Louisiana, Lafayette, LA 70504-4330, Phone: (318) 231-6603. An Equal Opportunity/Affirmative Action Employer.

The Citadel: The Department of Electrical Engineering at The Citadel invites applications for a tenure track position at the assistant professor level. Primary interest is in an individual with a strong commitment to undergraduate engineering education, and the ability and desire to teach in an undergraduate Electrical Engineering program that includes both day and evening classes. A Ph.D. is required and teaching and industrial experience are desirable. Applicants should be US citizens or have a permanent visa. The individual selected will have education and experience in one or more of the following areas: digital systems, microprocessor applications, instrumentation, energy systems, or analog and digital communications. Duties will include teaching a broad range of undergraduate lecture and laboratory courses. The Citadel currently offers no graduate courses in electrical engineering. Institutional support for research is available and consulting opportunities are available in the metropolitan Charleston area. The position may be filled as early as July 1994, but applications will be accepted until the position is filled. The Citadel, located in beautiful, historic Charleston, is a great place to work and Charleston is a wonderful place to live. Apply with letter stating professional objectives, resume, and names of three references to Dr. Harold W. Askins, Jr., Professor and Head, Department of Electrical Engineering, The Citadel, 171 Moultrie Street, Charleston, SC 29409. The Citadel is an equal opportunity, affirmative action employer. Women and minorities are encouraged to apply.

Electronics Engineering Technology. Tenure leading position at the Assistant Professor level in a rapidly evolving, rigorous TAC-ABET accredited Electronics Engineering Technology Associate and Baccalaureate degree granting program at the Omaha campus of the University of Nebraska/Lincoln. Qualifications: Requires earned Ph.D. in Electrical Engineering, Computer Engineering, or closely allied field, and relevant industrial experience. Must have demonstrated evidence of applied research and/or scholarly activity. Experience in telecommunications, digital signal processing, or computer architecture desirable. Resumes should be sent to Prof. R.D. Sash, Electronics Engineering Technology, Omaha Campus - University of Nebraska, Omaha, NE 68182-0181. Review of applicants will commence May 15, 1994. The University of Nebraska-Lincoln is committed to a pluralistic campus community through Affirmative Action and Equal Opportunity and is responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act; contact Prof. Sash for more information. You may forward your invoice to Prof. R.D. Sash, Electronics Engineering Technology, Omaha Campus - University of Nebraska, Omaha, NE 68182-0181.

Electrical Engineering: Geneva College is seeking candidates for a tenure-track position in electrical engineering. Candidates should have their highest degree in electrical engineering, Ph.D. preferred. Professional experience is also desirable. Geneva is a church-controlled college in the evangelical and Reformed traditions and seeks faculty members who share that perspective and want to develop their teaching and scholarship within that framework. Women and members of ethnic minorities are encouraged to apply. For more information, contact Dr. J. Gidley, Engineering Search Committee, Geneva College, Beaver Falls, PA 15010.

Western New England College, Electrical Engineering. Western New England College has an open full-time faculty position in Electrical Engineering. A tenure track appointment is possible. The desired area of expertise is Computer Engineering. A Ph.D. in Computer or Electrical Engineering is required. The ABET accredited EE program has computer options at the B.S. and M.S. levels. The position will involve teaching computer hardware and software courses and laboratories, and also requires the teaching of

some basic courses and/or laboratories in Electrical or Bioengineering. The Engineering School has a reputation for excellent instruction and personal attention to students. Rank and salary are commensurate with qualifications. Applicants must be eligible to work in the United States, either by citizenship, resident alien status, or appropriate visa. Send a comprehensive resume, official transcripts and names and addresses of three references to: Dean Stephen Crist, School of Engineering, Western New England College, 1215 Wilbraham Road, Springfield, MA 01119. Western New England College is an Equal Opportunity Employer.

Monterrey Institute of Technology, Mexico City Campus, (ITESM), is looking for candidates for positions as professors in Electrical Engineering, Computer Science, Computer Engineering, Information Sciences, Informatics, and Telecommunications. Minimum requirements: Ph.D. or M.S. in Electrical Engineering with specialty in Electronics, Computer Science, Digital Systems, or Information Systems. Ability to teach in Spanish. Competitive salaries, good benefits, travel to and from Mexico. Starting date - July, 1994. Send two copies of your resume, two copies of a letter of intent and transcripts to Dr. France J. Pruitt, U.S. Representative, P.O. Box 34430, Bethesda, MD 20827, Tel (301) 493-4982, Fax (301) 530-2461.

Chair, Department of Electrical Engineering. Applications are invited for the position of Chair, Department of Electrical Engineering, Wright State University, Dayton, Ohio. The department has 16 full time faculty, 382 undergraduate majors and 104 graduate students. Undergraduate degrees in Electrical Engineering and Engineering Physics are accredited by ABET. The EE Department is one of four departments in the College of Engineering and Computer Science. The college has a total enrollment of 1,468 undergraduate majors and 342 graduate students. The college programs are consolidated in a new engineering building with superb classroom, laboratory, office and computer facilities. An active research program is being conducted with significant external funding in several areas including image and signal processing, VLSI circuits, power electronics, applied communications, sensor fusion, control theory, robotics, microwave circuits, and electromagnetics. The position requires a Ph.D. in Electrical Engineering or closely related field with qualifications for advanced rank appointment in the department. A candidate must have a strong interest and dedication to educational programs at both the graduate and undergraduate level, a distinguished record in electrical engineering, and a demonstrated leadership ability in education and research. Applications should include a vitae, a statement of capabilities and qualifications, and names and addresses of at least three professional references. The salary is competitive. Wright State University is an equal opportunity/affirmative action employer. Address applications to: Dr. Ray Siferd, Search Committee Chair, Department of Electrical Engineering, Wright State University, Dayton, OH 45435. Tel: 513-873-5037. Email: rsiferd@valhalla.wright.edu. Review of applications will begin May 1, 1994 and continue until the position is filled or the search is terminated.

Laval University. The Department of Electrical Engineering invites applications for a tenure track position in the area of optical communications systems. The successful applicant will conduct research in photonic components and system applications under a joint university-industry program sponsored by Quebec-Telephone and the Natural Sciences and Engineering Council of Canada. The applicant will have a modest teaching load at both undergraduate and graduate levels. Requirements: hold a doctorate in engineering or science, and be skilled in both writing and speaking French. Apply by May 1, 1994, to: Mr. Denis Angers, Head, Electrical Engineering Department, Pavillon Adrien-Pouliot, Laval University, Quebec City, Quebec, G1K 7P4, Canada. Laval University is implementing a policy of employment equity. In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

The Franco-Polish School of New Information and Communication Technologies (EFP) invites applications for faculty positions at all levels including visiting professors and researchers. EFP, inspired by the French model of the Grande Ecole, was established in 1992 and is financed by a Foundation composed of French and Polish governmental institutions and companies (FRANCE TELECOM, ALCATEL, BULL, TPSA). EFP aims at educating internationally minded telecommunications and computer engineers sensitive to the economic and human aspects of their profession. EFP carries out vigorous applied research in telecommunications switching and networks, transmission systems (incl. mobile radio) signal processing, databases, software engineering, economics in telecommunications and technology transfer. EFP plans to establish research groups in multimedia, knowledge engineering and distributed systems. Openings exist in all these areas. The three final semesters are taught in French, with some lectures in English. Send your resume, including a statement of research and teaching interests and names and addresses of three references to: Jan Glinski, Rector, The Franco-Polish School of New Information and Communication Technologies, ul.Mansfelda 4, 60-854 Poznan, Poland. Fax: +(48)(61)48 35 82. email: rector@efp.poz.edu.pl

Rose-Hulman Institute of Technology. The Department of Electrical & Computer Engineering invites applications for both tenure-track and visiting positions beginning mid-August 1994. A Ph.D. in Electrical or Computer Engineering is required. Preferred areas of expertise are Computer Architecture, Digital Signal Processing and Electromagnetics. Rose-Hulman is a highly selective college of science and engineering with approximately 1400 students enrolled in BS and MS programs. Faculty members are expected to be outstanding educators capable of providing talented students with a first class education in the classroom and in the laboratory. Professional development is expected of all faculty. Application screening will begin April 18, 1994. Prospective applicants may obtain detailed additional information about Rose-Hulman, the Department of Electrical & Computer Engineering, and application procedures from: Dr. Barry Farbrother, Chairman, Electrical & Computer Engineering, Rose-Hulman Institute of Technology, 5500 Wabash Avenue, Terre Haute, IN 47803-3999. Phone: (812) 877-8414. Fax: (812) 877-8895. E-mail: barry.farbrother@rose-hulman.edu

Memorial University of Newfoundland, Electrical Engineering. Applications are invited for two appointments with a three-year term each, commencing September 1994, in the areas of i) computer engineering with specialization in software engineering of real-time and distributed systems, object-oriented systems, computer networks, or computer architecture; ii) industrial control and instrumentation with primary interests in digital control, motor control, process control, robotics, instrumentation, or design of industrial control systems. The successful applicants will be expected to teach undergraduate and graduate courses, conduct research, and participate in other educational, scholarly and professional activities. Applicants must have a Ph.D. in Electrical Engineering and have a demonstrated ability to complement and expand the existing areas of expertise. Industrial and/or teaching and research experience is desirable. The successful candidates are expected to have or seek professional registration with the Association of Professional Engineers and Geoscientists of Newfoundland. The Electrical Engineering discipline has well-established co-operative undergraduate and active graduate and research programs in power devices and systems, applied electromagnetics, digital systems and VLSI, and a proposed undergraduate option in computers and communications. Applicants should submit a curriculum vitae with the names of at least three referees, and three representative publications to: Dr. R. Seshadri, Dean, Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St. John's, Newfoundland, Canada, A1B 3X5. Fax #: (709)737-4042. References: ELEC-94-02 (Computer Engineering). ELEC-94-03 (Industrial Control and Instrumentation). These positions are subject to budgetary approval. The closing date for applications is April 30, 1994. In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents of Canada. Memorial University of Newfoundland is committed to employment equity.

The Research Computing Group is seeking applicants for the position of Research Assistant Professor/Associate Director to assist in directing group collaborative research. Salary is $50,000/yr. This position provides a broad spectrum of research opportunities in academic, industrial and government projects. The major goal of the Research Computing Group is to assist in the transfer of technology and in the application of advanced software techniques. This position offers the opportunity for independent research in a stimulating scientific environment. Current systems include communication network simulators, visual databases for fiber optics networks, a Research Centers Management Information System, electric load projection and power production simulators, a client/server development system with a graphics user interface. Job Duties: To perform research and development for new production systems and software development methodologies. To direct and supervise analysts, programmers and graduate students in the development and maintenance of new/existing production software systems that are heavily involved in the object-oriented paradigm. Application areas include data communication, networking, client/server models, database, simulation, language design, and GUI. The successful candidate is expected to hold seminars in advanced computing technology, especially OOA/D/P and network protocols, to consult with industry leaders, and to assume a leadership role in the pursuit of internal and external funding of research projects. Job Qualifications: Ph.D. in Computer Science with a Bachelor's or Master's degree in Electrical, Mechanical, or Civil Engineering. Graduate coursework in data communication/networking, information theory, and computer language design/compilers. Minimum 2 years experience in analysis, design and supervising development of production systems using the object oriented paradigm and C++. Demonstrated ability: 1.) to analyze systems that utilize communication networks, graphics user interface (X and MS windows), and system databases; 2.) to assume a leadership role in group projects involving complex system analysis; and 3.) to conduct seminars and provide consultation in the area of OOA/D/P. Send resume and names and addresses of three professional references to: Associate Dean Samy E.G. Elias, Engineering Research Centers (RCG), W150 Nebraska Hall, University of Nebraska-Lincoln, Lincoln, NE 68588-0502. Deadline is April 29, 1994 (or until suitable candidate is found). The University of Nebraska-Lincoln is committed to a pluralistic campus community through Affirmative Action and Equal Opportunity and is responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act; contact Associate Dean Samy E.G. Elias at the above address for more information.

Academia Sinica's Inst. Astronomy & Astrophysics (ASIAA) intends to develop modern astronomical instrumentation with an initial emphasis on mm and sub-mm wave interferometry. Applications are sought from experimental or applied physicists, engineers, or instrumentalists with expertise in mm- and sub-mm wave receivers, thin-film deposition, UV and e-beam lithography, cryogenics, digital correlators, or microwave engineering. Practical experience in system integration is required. Please send resume including details of past projects and three references to Dr. Typhoon Lee, ASIAA, P.O. Box 1-87, Nankang, Taipei, TAIWAN or "ASIAA@biaa3.biaa.sinica.edu.tw." (Fax: 886-2-7881106)

University of New Orleans, Department of Electrical Engineering invites applications for new positions anticipated to be established in the areas of Electric Power, Photonics and Elec-

trooptics, Analog and Digital Signal Processing, and Solid State Devices beginning Fall 1994. These positions are subject to the availability of future funding. Successful candidates will be expected to direct graduate research, develop externally funded research, and teach graduate and undergraduate courses. Applicants must have an earned doctorate in the area of specialty with a BS in Electrical Engineering preferred. Salary and academic rank will be commensurate with experience and qualifications. Interested persons should send a resume with names, addresses, and phone numbers of three references to Dr. Paul M. Chirlian, Chairman, Department of Electrical Engineering, College of Electrical Engineering, University of New Orleans, Lakefront, New Orleans, LA 70148. The University of New Orleans is an Equal Opportunity/Affirmative Action Employer.

Electrical Engineering: Bucknell University invites applications for sabbatical leave and junior faculty leave replacement positions at the visiting Assistant/Associate Professor level for at least one year. We are seeking student-oriented individuals with excellent teaching records in the classroom, in the laboratory, and with design experience. Preferred areas include digital, control systems, instrumentation, power, electronics, electromagnetics, machines, circuits, systems and VLSI. Qualifications include a Ph.D. in Electrical or Computer Engineering. Bucknell is a private university emphasizing quality undergraduate education in engineering and liberal arts. Review of applications will begin immediately and will continue until the positions are filled. Please send applications to: Chair, Search Committee, Electrical Engineering Department, Bucknell University, Lewisburg, PA 17837. Women and members of minority groups are especially encouraged to apply.

III-V Optoelectronic Material Processing Scientist. The Department of Electrical Engineering at The University of Maryland, College Park, has embarked in a major initiative in the area of optoelectronic devices and applications. One of the major goals is the demonstration of an optical WDM network in a high performance distributed shared memory computing environment. We are seeking applicants with experience in the areas of dry etching, plasma enhanced chemical vapor deposition, metallization, and optoelectronic device design, fabrication and testing. The candidate should be familiar with optoelectronic device fabrication (lasers, semiconductor amplifiers, detectors, PICs and OEICs), innovative components research and optoelectronic packaging. The position is a 2-year research scientist appointment with possibility of renewal, subject to availability of funds. Candidates must have a Ph.D. and should have a strong desire to work on collaborative research projects. Applicants should submit a resume, the names, addresses, and telephone numbers of three references, to: Professor M. Dagenais, Department of Electrical Engineering, University of Maryland, College Park, MD 20742 (Tel: 301-405-3684; FAX: 301-314-9281). The University of Maryland is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

Heinrich-Hertz-Institut fur Nachrichtentechnik, Berlin (Germany) invites applications for the position of head of the optical switching/routing department. Minimum qualifications are an earned doctorate degree in electrical engineering or physics or equivalent educational background. Extensive system-oriented experience in various areas of communications technology including optical communications is required as well as proven capability and long-term experience to lead large groups of scientific and technical staff members. The candidate should cooperate in the development of medium- and long-term research concepts and in their subsequent realization. Finally readiness to apply modern management techniques and to reinforce cooperation between different groups within and outside the institute are mandatory. The position is available immediately and the salary may be up to US $75,000/yr. Please send applications to: Heinrich-Hertz-Institut fur Nachrichtentechnik Berlin GmbH, Einsteinufer 37, 10587 Berlin, Germany.

Systems Designer: Designs, fabricates, tests electronic instruments including analog and digital, low to high voltage, DC to high frequency circuits; modifies existing equipment; acts as technical resource for faculty, staff, students to support research and teaching in chemistry. Required: Bachelor's degree, electrical engineering; five years related and progressively more responsible or expansive work experience in analog and digital electronic equipment design, circuit techniques, component selection, fabrication, testing; use of specialized scientific equipment; ability to analyze schematics. (Applicants with equivalent combination of education and experience encouraged to apply.) Desired: Experience in microcomputing and computer aided design software. Please call (517) 336-1662 for application, refer to Posting P30001. Salary minimum is $32,959.00. Closing date is May 15, 1994. Michigan State University is an Affirmative Action/Equal Opportunity Employer.

University of California at Santa Barbara. The College of Engineering is in the process of developing an interdisciplinary graduate program aimed at education and research at the intersection between applied mathematics, numerical analysis, computer science, and the application of computational methods to the solution of problems in science and engineering. The College is seeking a faculty member to develop and lead the program. The level of the position is open. Multi-departmental appointments are possible. Senior candidates should have established an international reputation in an area within the broad framework of the program. Junior candidates should have outstanding research potential. Applicants should send their resumes and the names and addresses of at least four professional references to: Search Committee in Scientific Computation, Dean's Office, College of Engineering, Engineering I, Rm. 1016, University of California, Santa Barbara, CA 93106. Applications and nominations will be received until the position is filled. UCSB is an equal opportunity, affirmative action employer.

The Ohio State University Department of Electrical Engineering invites applications for the Neal A. Smith Endowed Chair in Electrical Engineering at the rank of Professor. Distinguished scholars with outstanding research and teaching records in all areas of Power Engineering are encouraged to apply. The individual selected will be expected to establish and maintain a significant research effort at OSU and teach both undergraduate and graduate-level courses. This Department has 42 faculty members with total annual research funding of $5.5 million. The Power area has four faculty members with external funding of $400K per year. Research areas include electric machines and control, high voltage engineering, power electronics, and power system protection. Research and teaching facilities include a modern high-voltage laboratory scheduled for completion in Spring 1994. Send resume and names and addresses of references to Professor Robert E. Fenton, Chairman, Personnel Committee, Department of Electrical Engineering, The Ohio State University, 2015 Neil Avenue, Columbus OH 43210-1272. Evaluation of applications will begin 1 September 1994. The Ohio State University is an equal opportunity/affirmative action employer.

St. Petersburg Junior College. Vice President, Technology. Organizes, directs, integrates, and evaluates college-wide use of all technologies in college programs, instructional use, and services, and in academic and administrative computer operations. Requirements: Successful candidates should have management experience in a cross-platform environment, including some experience with mainframes, mini-computers and micro-computers, and expertise in the areas of data communications, networking, and distance learning. Preference will be given to candidates with experience in those computer systems currently used by the College. Preference will also be given to candidates who have senior level management experience with college or university computing. Minimum of five (5) years experience in the management of technology. Master's Degree in an appropriate discipline preferred; however, in lieu of educational requirement, an appropriate background in computer systems management and the use of computer-related technology in educational and instructional areas are acceptable. To Apply: Please send a resume and cover letter to: Human Resources, St. Petersburg Junior College, P.O. Box 13489, St. Petersburg, FL 33733. Application Deadline: Applications must be postmarked on or before April 8, 1994. Anticipated Start Date: As soon as possible.

Electrical Engineering (VLSI): The Department of Electrical and Computer Engineering, Graduate School of Engineering, at the Air Force Institute of Technology, Wright-Patterson Air Force Base, Dayton, Ohio. Applications are invited for a tenure track position at the Assistant or Associate Professor level, effective immediately. Emphasis of this position is in the area of Very Large Scale Integration (VLSI) of microelectronic circuits. Applicant must have an earned doctorate in Electrical or Computer Engineering or a related specialty. Position requires teaching at the graduate level and carrying out research under the sponsorship of government agencies. This department has close working relationships with Air Force and Department of Defense research and development organizations. In particular, the selected individual is expected to work closely with research and development organizations specializing in VLSI and VHDL. The department has excellent laboratory facilities for integrated circuit design and testing. Computational facilities are of the highest caliber, and are continually being expanded. Applicants should be U.S. citizens. Salary will be commensurate with experience. Submit a complete resume and the names of three references to: Dr. Peter Maybeck, Search Committee Chairman, Department of Electrical and Computer Engineering, AFIT.ENG, Wright-Patterson AFB OH 45433-6583. The United States Air Force is an equal opportunity, affirmative action employer.

Johns Hopkins University, Biomedical Engineering. Biomedical Sensors/Instrumentation. The Department of Biomedical Engineering at the Johns Hopkins University School of Medicine is seeking candidates for a tenure-track faculty position at the Assistant Professor level with interests in the areas of Biomedical Sensors and Instrumentation. The successful candidate will be expected to build an independent research program, teach courses in biomedical sensors and instrumentation. Applicants should send their CV and three letters of reference to: Dr. Murray B. Sachs, Biosensors/Instrumentation Search, Department of Biomedical Engineering, Johns Hopkins School of Medicine, 710 Traylor Bldg., 720 Rutland Avenue, Baltimore, MD 21205. The Johns Hopkins University is an Equal Opportunity/Affirmative Action Institution.

Microfabrication Engineer/Scientist. The Physics and Astronomy Department at Michigan State University is seeking a person to manage a microfabrication facility with electron-beam and optical lithographies and with electron imaging and analysis. Instrumentation includes JEOL 840A and ISI SX40 SEM's equipped for electron-beam writing under computer control, and a VG 501 FESTEM. Responsibilities include: operation and maintenance of electron beam and optical lithography devices; development of electron-beam lithography techniques; training and overseeing students in lithography and microscopy; and participation in research programs with faculty and students. Requires a B.S., M.S. or Ph.D. in physics, engineering or a closely-related field, one to three years experience with electron-beam lithography and electron microscopy, and the ability to work independently. Additional experience in condensed matter physics (x-ray, electronics, spectroscopy) or in analytical electron microscopy will be viewed favorably. Call 517-336-1662 for an application. Refer to position # P40026. MSU is an Affirmative Action/Equal Opportunity Employer.

Faculty Position, Reliability Engineering, University of Maryland. Applications are invited for a tenure track faculty position at the Assistant or Associate Professor level at the University of Maryland. We are particularly interested in receiving applications from women and minorities. The position is in the Reliability Engineering Program of the Department of Materials and Nuclear Engineering. With increasing competition and emphasis on the quality of products, there is need for research that will lead to a strong foundation to support improved reliability of commercial products. The successful candidate will conduct research in the area of

CLASSIFIED EMPLOYMENT OPPORTUNITIES

advanced product reliability, and it is expected that the output of this research will be transferred to industry where it will contribute to improved product reliability. Since the reliability of products is intermingled with design, manufacturing, software, physics of failure, cost, etc., the desired individual should be capable of dealing with the various factors that contribute to the overall reliability of products. The successful candidate will also be expected to teach courses in Reliability Engineering, Quality and Reliability in Manufacturing and Product Reliability. A strong industrial interaction and ability to work with other research and development personnel will be required along with the ability to address industrial reliability issues. The successful candidate should be prepared to conduct a vigorous research program and must have the capability to attract outside funding for research projects. Applicants should have an earned doctorate in engineering or an appropriately related discipline. Interested applicants may send their CV's and names of three references to: Dr. Behnam Pourdeyhimi, Chair of the Search Committee, Department of Materials and Nuclear Engineering, University of Maryland, College Park, MD 20742. Evaluation of applications will begin in May, and it is expected that the position will be filled for the Fall 1994 term.

University of Oklahoma, Hughes Professorship, in information technology. The School of Electrical Engineering is soliciting nominations and applications for an endowed professorship in the area of information technology beginning August 1994. The person filling this professorship will be involved in teaching and research in the area of information technology which includes information networks, telecommunications, information management and related areas. The candidate is expected to play a leading role in the School as well as provide leadership in graduate educational programs in the telecommunications and information technology areas. The endowment for the Hughes Professorship as well as the existing research and educational programs will provide an exciting opportunity for qualified candidates. Candidates for the Hughes Professorship must have a Phd in electrical engineering or related area, be teachers and researchers of distinction with a record of significant achievements in the field and have demonstrated the ability to attract external funds. Candidates with either industrial and/or academic experience in one or more of the topics included in information technology are encouraged to apply. Experience in emerging areas such as wireless and personal communications, high-speed and multi-media networks and systems are of particular interest. Deadline for applications is April 15, 1994, but the search will continue until a suitable candidate is found. Please send nominations and applications with four references to: T.E. Batchman, Director, School of Electrical Engineering, University of Oklahoma, 202 W. Boyd Rm 219, Norman, OK 73019-0631. The University of Oklahoma is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply. OU has a policy of being responsive to the needs of dual-career couples.

Program Manager, Large Millimeter Telescope, University of Massachusetts at Amherst. The University is seeking a Program Manager/Staff Administrator for the $43 million Large Millimeter Telescope project. The project aims at designing and building the world's largest radio astronomy telescope for use at short millimeter wavelengths. The project is an equal partnership between the University of Massachusetts and institutes in Mexico, and the telescope will be sited in Mexico. The LMT will be the first radio telescope built with an active segmented surface under continuous computer control, and it will be equipped with state-of-the-art array receivers for spectroscopy and continuum observations. Funding will come from the government of Mexico, the U.S. federal government, and the Commonwealth of Massachusetts. The Program Manager will be located at the University of Massachusetts at Amherst, with appropriate liaison with Mexico and with industrial partners. The Program Manager will report to the Principal Investigators for the project and will, with an appropriate staff, be responsible for contract management, technical supervision, planning and scheduling, and purchasing and fiscal matters. The anticipated length of the project design and construction phase is five years. Applicants should have appropriate technical background, experience in managing large technical projects, familiarity with federal government regulations and procedures, and experience with a university environment. Fluency in Spanish and familiarity with Mexico, and/or experience in working outside the U.S., is desirable. Because travel to high altitude sites may be required. a medical exam may be a pre-employment requirement. Salary commensurate with experience. This is a renewable contract, state-funded and benefitted position. Applicants should include a cover letter, resume, at least three letters of reference, and names of additional references. Send applications to Dr. William Irvine, Five College Radio Astronomy Observatory, 619 Lederle Graduate Research Center, University of Massachusetts, Amherst, Massachusetts 01003. Reply by May 1. The University of Massachusetts is an Affirmative Action/Equal Opportunity Employer.

Faculty and Post Doctoral Positions in Bioengineering. Whitaker Foundation Special Opportunity Award "Symbiosis of Biomedical and Bioprocess Engineering Utilizing the TQM Strategy". The College of Engineering at the University of Maryland Baltimore County (UMBC) is seeking individuals to fill two faculty positions, a post doctoral position, and several Ph.D. graduate student assistantships available immediately. Position applicants must have a Ph.D. degree in a biorelated field (bioprocess, biomedical, biomechanical or bioelectrical engineering). Broad formal training in bioengineering which includes biomedical and bioprocess engineering will be given high priority. The positions will involve teaching at the undergraduate and graduate level and require the establishment of an externally funded research program. The College has state-of-the-art facilities including the recently opened 26 million dollar Engineering and Computer Science building. The campus is conveniently located near BWI international airport, a number of federal laboratories and local industry. Applicants should send a C.V., statement of teaching and research interests and names/addresses/telephone numbers of three references to: Duane F. Bruley, Dean/College of Engineering, University of Maryland Baltimore County, 5401 Wilkens Avenue, ECS 314, Baltimore, Maryland 21228. Review of applicants will start in Spring 1994. UMBC is an Affirmative Action/EEO employer.

Director, Medical and Biological Engineering Program, Indiana University - Purdue University Indianapolis (IUPUI). Applications and nominations are invited for the position of Director, Medical and Biological Engineering (MBE) at the Purdue School of Engineering and Technology at IUPUI, available July 1, 1994. The Director will be responsible for developing the plan for the graduate program in MBE and to coordinate the research activities of the School faculty having interests in MBE. Applicants must have a Ph.D. in MBE or in a related discipline and meet the standards for a tenure appointment at the rank of associate or full professor in the School. Candidates must have a strong commitment to teaching and excellence in research. They should have demonstrated the ability to provide leadership for academic programs and to conduct innovative and collaborative research, as well as have excellent interpersonal and communication skills. Consideration will be given to candidates with a record for attracting external support and building collaboration among a diverse community of academic, industrial, and government groups. Applicants should submit a resume and a statement of academic accomplishments and career objectives in an accompanying cover letter to Dr. Wendell F. McBurney, Chair, Director MBE Search and Screen Committee, Indiana University Purdue University Indianapolis, ET 1219, 799 West Michigan Street, Indianapolis, IN 46202. Screening of applications will begin March 15, 1994, and continue until the position is filled. With 2,300 students, the School of Engineering and Technology is one of the largest of 18 academic units at IUPUI. IUPUI is a comprehensive urban campus that enrolls more than 27,000 students, offers 174 academic programs, and includes an internationally known medical center. On the IUPUI campus, the Indiana University Schools of Medicine and Dentistry offer the opportunity for collaborative multidisciplinary MBE research activities in areas such as biomechanics, biomaterials, medical imaging, and cardiovascular diagnostics and therapeutics. IUPUI resources include the Biomechanics and Biomaterials Research Center with 11 core support research laboratories and 41 faculty members; the Medical Imaging Research Group, in association with the Department of Radiology and the Indianapolis Center for Advanced Research (ICFAR); and the Krannert Institute of Cardiology. More than 1.2 million people live in metropolitan Indianapolis, which is not only the capital city but also the business and technical center of the state. Indianapolis has become a center for recreational activities, amateur sports and culture. It is the site of world class athletics with many held in IUPUI's Olympic and professional caliber aquatic, track, and tennis facilities. IUPUI is an Equal Opportunity, Affirmative Action employer. Women and minority candidates are encouraged to apply.

Electrical Engineering: Bucknell University invites applications for a tenure-track position at the Assistant Professor level. We are seeking an individual with promise as a teacher and researcher. Responsibilities include course and laboratory development and supervision of design projects, and supervision of master's theses. The preferred area is electromagnetics with specialization in the areas of optical systems or power systems. Qualifications include a Ph.D. in Electrical Engineering. Bucknell is a private university emphasizing quality undergraduate education in engineering and liberal arts. Review of applications will begin on March 1, 1994, and will continue until the position is filled. Please send applications to: Maurice F. Aburdene, Chair, Electrical Engineering Department, Bucknell University, Lewisburg, PA 17837. Women and members of minority groups are especially encouraged to apply.

Electronics Engineering Technology Instructor: To develop/instruct courses for EET Associate Degree Program accredited by TAC/ABET. Additional responsibilities include interaction w/ industry, participation in professional/academic activities, & student advising. Requires a master's degree in Electrical/Electronics Engineering; knowledgeable in circuit analysis, digital systems, & microprocessor applications; & recent relevant industrial experience. Previous teaching experience desired. Submit resume to: HR Dept SC124/Greenville Technical College/PO Box 5616/Greenville, South Carolina 29606-5616. EOE/AA/M/F/D/V.

Government/Industry Positions Open

Electrical/Electronic Engineer. A new R & D Laboratory located in the Tampa Bay area on the West Coast of Florida has immediate requirements for electrical/electronic engineers. Acceptable candidates must have recent and relevant hands-on experience and a demonstrated ability to advance the state of the art in fast analog and digital circuit design for nuclear detector systems. If you have at least a B.S.E.E. and want to work in a stimulating small company environment pushing the state of the art in hardware and packaging design and implementation and are willing and able to roll up your sleeves and dig in you are a potential candidate. Competitive salaries and an attractive benefit package offered. DoD security clearance required. Send resume in confidence to R & D Lab 10846 97th St. No. Largo, FL 34643 EOE M/F.

Sr. Computer Engineer for SW Ohio R & D contractor. Design, analyze and implement computer and computer system architectures in support of company's contract work and internal research and development. Will be principal investigator for projects, products and services involving Very High Speed Integrated Circuit Hardware Description Language, parallel discrete event simulators and object-oriented design and programming. M.S. Degree in Com-

puter Engineering with emphasis in Computer System Design. Two (2) years experience required. Experience may have been gained at any time and must have involved: use of Very High Speed Integrated Circuit Hardware Description Language; design, analysis and implementation of a parallel discrete event simulator. Included in the 2 years experience must have been 1 year in object-oriented design and programming. All experience may have been acquired concurrently. 40 hr/wk. 8:00 to 5:00, $24.30 to $29.40 per hour (depending on qualifications). Must have proof of legal authority to work indefinitely in U.S. Qualified applicants send resume in duplicate (no calls) to J. Davies, JO#1421054, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, OH 43216.

Engineer, R&D: Research & CAD tool prod dev for vlsi logic synth for ASIC design. PhD in EE or Comp Eng; or MS (or equiv in educ) in EE or Comp Eng + 2 yr exp in reltd post-MS research or study reqd. $5416/mo. 40 hr/wk. Knlg of logic synth s/w dev, VLSI logic des, algorthm & complexity analy, ASIC layout tchnlgy, genetic algorthm & simul anneal, tchnlgy map, & C on Unix reqd. Job site/intv: San Jose, CA. Send ad & resume to: IEEE Spectrum, Box 4-1, 345 E. 47th St., New York, NY 10017.

Help Wanted: Power Systems Engineer. By April 30, 1994, please send resume to: Employment Security Department, E&T Division, Job #407378, P.O. Box 9046, Olympia, WA 98507-9046. Job Description: Power Systems Engineer for the Power Systems Applications Team within the Technology Group to design, modify, code, test and document software in the generation (schedule/control/unit commitment) area in support of Energy Management Systems (EMS) projects for electrical utilities and value-added resellers. Maintain existing power systems generation application functionality, including code, documentation and user-interface by designing incremental changes to existing base system software and coding, testing and documenting the changes as well as diagnosing and correcting Software Performance Record (SDR). Implement pre-defined new functionality for energy management system software by coding, testing, and documenting. Develop software and user-interface to enhance existing functionality after the design has been specified by code design, documentation and internal testing. All work is done in the HABITAT development environment and primarily involves Automatic Generation Control (AGC). Requirements: Master's degree in Electrical Engineering to include: 20 course hours in Power Systems Engineering; 2 years experience in the power systems engineering field implementing and using AGC (Automatic Generation Control); 1 year experience working with the HABITAT development environment; 6 months experience or 10 course hours in VMS operating system, Fortran language and VAX family computers. (All experience may be gained concurrently.) Cover letter/resume must reflect all requirements. Must have proof of legal authority to work in the United States. Salary Range: $37,748 - $51,817 per year. 40 hours per week, 8 a.m. to 5 p.m., M-F. Position in Bellevue, Washington. EOE.

AT&T Global Information Solutions is seeking a motivated individual for our Columbia, South Carolina engineering facility. The desired candidate will have a Ph.D. in Electrical or Computer Engineering, and at least two years of industrial experience in the following areas: a broad understanding of computer architecture; detailed knowledge of the Intel Pentium instruction set; detailed knowledge of the CPU-memory subsystem in shared memory multiprocessors - with particular emphasis on multilevel multiprocessor cache protocols; experience in hardware trace analysis; knowledge of industry-standard benchmarks including TPC and SPEC; and development and use of trace-driven multiprocessor cache performance simulators. The ideal candidate must also have detailed knowledge of several system interconnect techniques including the emerging IEEE STD 1596 standard; multiple issue microprocessors; experience in computer system performance analysis; discrete event computer system modeling and simulation; statistical analysis; and fault tolerant systems. At least 1 1/2 years experience in the use of SES/workbench and SAS data analysis tools is required. AT&T Global Information Solutions offers competitive salaries and benefits. As an equal opportunity employer, we value diversity. For confidential consideration, please send your resume and salary history to: Pam Jefferson, Human Resources Dept. S494, AT&T Global Information Solutions, 3325 Platt Springs Road, West Columbia, SC 29170.

Senior Software Engineer. Research/implement network applications in TCP/IP; research SNMP/hub mgmt software as it relates to IEEE reqmnts; identify reqmnts in firmware/software for standalone CPU project (including bridge devlpmt); research Novell Netware/Unix environments; design software drivers for LAN hardware; provide/maintain documentation for projects; provide training for employees in use of equipment designed; maintain proficiency in technical/analytical tools (protocol analyzer, emulator, logic analyzer and debugging tools). Reqmnts are: B.S. in Compu. Sci. or Electrical Eng'g; and 3 years 6 mos experience in job offered and in C and Assembly programming languages. Salary $55,000 annual, 8:00 a.m. to 5:00 p.m., M-F, 40 hrs/wk. Send resume to Mr. R. Tibbetts, # 3-149, MDJT, Room 207, 777 East Lake Street, Mpls, Minnesota 55407.

Electrical Engineer, Power Systems: Will design and develop power switches and power control systems to be installed as part of a multi-power control systems. Will discuss with customer particular needs and establish customized multi-power systems to insure a constant source of power where primary system may fail. Will develop appropriate systems for use in medical or other emergency buildings such as fire stations, schools, and other public buildings depending upon power supply system. All systems development will be done using CAD. Requires Master's degree in Electrical Engineering. Also requires six months experience in the job to be performed or six months experience as an Electrical Engineer. Education to include six months in designing systems control using CAD. If experience in related field, entire experience must include the design of industrial and residential electrical distribution systems including calculation of system fault currents and system load flows in connection with establishing remote control system of power regulation., Hours: 8:00 a.m. - 4:30 p.m. 40 hours per week at $37,145.00 per year salary. Must have proof of legal authority to work permanently in the U.S. Please send two copies of resume to: Illinois Department of Employment Security, 401 S. State St. - 3 South, Chicago, IL 60605, Attn: Len Boksa, Ref. #V-IL 11211-B, An Employer Paid Ad.

Engineering Specialist I: Research & design to identify technical problems & proper technical approach. Utilize C programming in a Unix computer platform, perform algorithm design, implementation, testing, interface with software engineering, SQA for product development. Ph.D in Electrical or Computer Engineering and 1 yr exp in job or 1 yr related computer research or equiv. Strong background in C, Unix computer platforms, SQA, neural networks, associative memories, computer vision, pattern recognition, signal processing, artificial intelligence. Salary: $4,583.00 per month. Job site/interview: Anaheim, Calif. Send ad & resume to job # CL 40182, P.O. Box 269065, Sacramento, Calif. 95826-9065.

Electrical Engineering Opportunity. Senior Electrical P.E. with experience in power, lighting, life safety systems for building design. Health care design a plus. Position will require supervision of project development and client contact, as well as overseeing production of contract documents and provide construction review to insure design schemes meet client needs. Must have 10 years design experience in building systems. FL registration preferred or capability of being registered in FL. Position is in FL branch office of 145 person E/A firm. Send resume to: Henry V. Liles, Jr., P. E., Daly Gonzalez Group, Inc., 12995 S. Cleveland Avenue, Suite 287, Ft. Myers, Florida 33907. M/F EOE.

Electrical Wiring Systems Engineer. Work schedule 6:30 A.M. - 3:15 P.M. 40 hours/week. $35.00 P/HR. Plan and design high/low voltage electric world car wiring system, including electric circuitry, cable, convolute tubing/channels, and packaging of all electrical components, including navigational aid and anti-lock braking system. Develop wiring partitioning and dedicated formed channels within composite body structures through floor pan and rear of vehicle, and temperature limitations of irradiated cross link cabling under hood engine environment. Develop fusing/grounding, electrical magnetic (EMI)/radio frequency interference (RFI) strategies, lighting, and electrical homologation requirements within U.S. and European standards, Direct 3 Electrical and 2 Design Engineers. Two years college Electrical Engineering Technology. Three years experience either in job or related occupation of Automotive Electrical Design Engineer. Three years of Job or Related Occupation experience shall include three years of experience in design engineering and development of automotive passenger car or commercial vehicle wiring harness electrical systems with related electrical/electronic component packaging of which one year shall include wiring of vehicle airbags, which three years of experience may be concurrent with Job or Related Occupation experience. Employee Paid Ad. Send resume to Job Service, 7310 Woodward Avenue, Room 415, Detroit, MI 48202, Reference No. 112593.

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account plans, assists in sales closes at management & executive levels. Provides leadership in resolution of customer issues & works with all levels of Customer Service organization to ensure customer satisfaction. Supervises work of 3-4 Technical Consultants (Sales Engineers). Develops & implements training of new technical staff members. Prioritizes & allocates resources & develops staffing plans. Develops technical marketing plans & programs, including sales seminars & workshops & new product demonstrations & develops sales models & tools to shorten & focus sales cycle. Req: A.A. degree or equivalent in Computer Technology or Computer Programming. Must have 4 years' experience as Sales Engineer (Software) or Systems Administrator. Experience must include 2 years' management experience. Must have knowledge of the client/server industry, RDBMS products, UNIX, MVS/CICS, PC operating systems & Network Operating Systems. Must have knowledge of software used in oil/gas industry. Salary: $75,000/year. Job site & int.: Irving, TX. Apply at the Texas Employment Commission, Dallas, Texas or send resume to: Texas Employment Commission, TEC Bldg., Austin, TX 78778, J.O. #TX6863810. Ad Paid by An Equal Employment Opportunity Employer.

Development Staff Member (Rochester, MN). Provide performance improvement and positioning guidance for existing and future products. Analyze software designs and hardware architectures. Evaluate performance through stochastic analysis, queuing models, and discrete event simulations. Influence performance of client/server products, object oriented development, distributed databases, distributed algorithms and multiprocessing. Ph.D. in Computer Science plus 1 year in job or 1 year as a Graduate or post-graduate Research Assistant. One year experience must include performance analysis, analytical modeling, the development of queuing models & stochastic simulations (discrete events & time-steps), distributed multiprocessing & client/server systems, research in distributed algorithms & heuristics, object technology, distributed & shared memory environments and load balancing. 40hr/wk; 8:30 a.m. - 5:00 p.m., $61,200/yr. Must be authorized for permanent employment in the United States. Please send cover letter and resume to: S. Springmeyer #3-233, MDJT, 390 North Robert St., 3rd Floor, St. Paul, MN 55101.

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Senior Program Manager; by May 1, 1994; Please send resume to: Employment Security Department, E&T Division, Job # 411854-F, P.O. Box 9046, Olympia, WA 98507-9046. Job Order Number must be indicated on your response. Job Description: Coordinates development of CD-ROM multimedia titles for micro computers. Designs functional product specifications and manages internal and external resources, including software design engineers, editors, graphics artists, animators, and user education staff, to design and build multimedia titles from conception through product release. Solicits, reviews, and evaluates contract proposals from independent vendors and software developers for development of CD-ROM multimedia titles in the United States and abroad. Utilizes "C" and windowing operating systems. Requires 20% international travel. Requirements: Bachelor's degree in Computer Science, Humanities or Media Studies; 5 years of work experience in technical, financial and resource management of computer applications products development to include 2 years experience in design and implementation of multimedia/hypertext applications from product conception through completion, to include 6 months experience or minimum of semester long or equivalent school thesis project experience in programming or computer software design utilizing "C" language and running on a windowing operating system. Experience may be gained concurrently. Must have legal authority to work in the United States. Job Location: Seattle area employer. Salary: $60,000-$64,000 per annum, depending on experience. Compensation package includes bonuses and stock options. 40 hours per week, flex time. EOE

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Scanning
The Institute

Ombudsman available for help solving problems

Any member who has a problem with the IEEE and has been unable to get it resolved now has an ombudsman to turn to for help. Luis T. Gandia was appointed by IEEE President H. Troy Nagle to investigate complaints and help arrange equitable settlements.

Gandia, who will serve to the end of 1994, was earlier elected the Institute's Secretary for 1994. He is president of L. Gandia & Associates Inc., a leading representative in San Juan, P.R., of major electrical and communications equipment manufacturers. Gandia also has a wealth of volunteer experience within the IEEE, most recently as Vice President–Regional Activities for 1992–93.

Gandia can be reached by e-mail at "ombudsman@ieee.org"; by writing to Ombudsman, IEEE, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855; by calling 800-678-IEEE and asking for the ombudsman; or by fax, 908-981-9721.

All complaints will be treated as confidential. The ombudsman will report periodically to the IEEE's Executive Committee on the state of complaints and on how they are resolved.

IEEE on the air

Help the IEEE attract new members by asking aspiring engineers, graduate students, and young, working EEs to watch the cable program "ComputerWatch" on May 7 on the CNBC channel in the United States. During the program, an IEEE commercial promoting the benefits of IEEE membership will be run.

The commercial will offer a complimentary copy of *IEEE Spectrum*'s January 1994 technology update issue, along with an IEEE introductory brochure, membership qualification information, and an application form. The offer will be limited to those who respond within 2 hours of the end of the program. Check your local television listings for the broadcast time in your area.

Electro show in Boston

The IEEE's big annual international show and convention, Electro International '94, takes place at the Hynes Convention Center in Boston, May 12–14. A key focus of the show will be how to reach the world market.

The conference program will offer nine broad-based tracks ranging from engineering technologies to careers and education, software, standards, networks, and manufacturing processes. Also featured will be the issues involved in international business and purchasing, while a business program, designed for senior executives and entrepreneurs, will discuss global forces and influences into the year 2000.

Over 600 companies in more than 3300 square meters of exhibition space will show products in all facets of electronic design, advanced packaging, fabrication and assembly, test, and contract manufacturing. More than 15 000 people are expected to attend the meeting, whose sponsors include Region 1 of the IEEE and the New England and New York Electronic Representatives Associations. For information on the conference, contact Miller Freeman Inc., 13760 Noel Rd., Suite 500, Dallas, TX 75240; 800-223-7126.

Coming
in Spectrum

RUSSIA'S CIVIL NUCLEAR INDUSTRY. The article's author was a name in USSR industry. Now he's in California, at a research institute in Monterey, and reports on the nuclear power situation in the post-Communist, post-Chernobyl era.

REUSING SOFTWARE. In spite—or because—of shrinking budgets, more is being asked of systems and the software that runs on them. The reuse of such elements as specifications, designs, codes, and tests has profited several organizations. Not only did productivity and quality rise, but development and maintenance costs fell. Here's how to start a reuse program.

ALTERNATIVES TO LAYOFFS. When sales drop below forecast and the red ink flows, are layoffs the only—or even the best—way to fix a company's problems? Probably not. In fact, alternative courses of action may even help prevent future difficulties. This article reviews the options, citing the recent experiences of several electronics companies, including two industry giants.

BIPOLAR SPIN TRANSISTORS. The basic operating principles of these novel devices are explained, a prototype is demonstrated, and their applications as memory element, logic element, and amplifier are presented. They are part of the future of semiconductors, especially the nonvolatile RAM, or NRAM.

PERSONAL COMMUNICATIONS. In a landmark decision last September, the Federal Communications System laid down rules for the formation of the personal communications system (PCS) industry. They included the size of geographical service areas, quantity of radio spectrum allocated for licensed and unlicensed PCSs, and construction requirements. This article will discuss the present state of the industry and what's likely to happen next.

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